DRAFT FINAL

PILOT STUDY REPORT

CAPE CANAVERAL AIR STATION

PERMEABLE REACTIVE TREATMENT (PeRT) WALL PILOT STUDY

Prepared for:

THE AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

Prepared By:

RUST ENVIRONMENT & INFRASTRUCTURE
GREENVILLE, SOUTH CAROLINA

Rust Project No. 29515

Contract No. F41624-94-D-8048
Delivery Order No. 10

Revision 2

NOTICE

This Pilot Study Report has been prepared for the United States Air Force (USAF) by Rust Environment & Infrastructure (Rust) for the purpose of aiding in the implementation of a final remedial action plan under the Air Force Installation Restoration Program (IRP). As the Pilot Study Report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this Pilot Study Report and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report since subsequent facts may become known that may make this report premature or inaccurate.

Copies of this report may be purchased from:

a. Government agencies and their contractors registered with the Defense Technical Information Center (DTIC) should direct requests for copies of this report to: Defense Technical Information Center, Cameron Station, Alexandria, VA, 22304.

b. Non-Government agencies may purchase copies of this document from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Environmental Excellence
ARARs	Applicable or Relevant and Appropriate Requirements
bls	Below Land Surface
CCAS	Cape Canaveral Air Station
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	Corrective Measures Study
CPT	Cone Penetrometer Technology
DCA	1,1-dichloroethane
DCE	1,1-dichloroethene
DCB	dichlorobenzene
c-DCE	cis isomer of 1,2-dichloroethene
c/t-DCE	total of cis and trans isomers of 1,2-dichloroethene
t-DCE	trans isomer of 1,2-dichloroethene
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DO	Dissolved Oxygen
DOD	Department of Defense
DOT	Department of Transportation
DTIC	Defense Technical Information Center
EPA	United States Environmental Protection Agency
ETI	EnviroMetal Technologies, Inc.
Fe^{+0}	Iron, zero valent
Fe^{+2}	Iron, II valent
ID	Internal Diameter
IDW	Investigation Derived Waste
IRP	Installation Restoration Program
IRPIMS	Installation Restoration Program Management Information System
JAG	Jet Assisted Grouting
MCL	Maximum Contaminant Level
msl	Mean Sea Level
NCP	National Contingency Plan

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

ND	Non-Detect
O&M	Operating and Maintenance
ORP	Oxidation-Reduction potential
OU	Operable Unit
OVA	Organic Vapor Analyzer
Parsons ES	Parsons Engineering Science
PeRT	Permeable Reactive Treatment
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act of 1976
RFI	RCRA Facilities Investigation
RI/FS	Remedial Investigation/Feasibility Study
Rust	Rust Environment & Infrastructure
SARA	Superfund Amendments Reauthorization Act of 1986
SOW	Statement of Work
SSI	Slurry Systems, Inc.
TCA	1,1,1-Trichloroethane
TCE	Trichloroethene
TDS	Total Dissolved Solids
USAF	United States Air Force
VOC	Volatile Organic Compounds

UNITS OF MEASURE ABBREVIATIONS

µg/L	Micrograms per Liter
°	Degrees
°C	Degrees Centigrade
cf	Cubic foot or cubic feet
gpm	Gallons per minute
psi	Pounds per square inch (gage unless otherwise stated)
mv	Milli-volts

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

UNITS OF MEASURE ABBREVIATIONS (CONTINUED)

°F	Degrees Fahrenheit
mg/L	Milligrams per Liter
%	Percent
umhos/cm	Micro-mhos per centimeter
S.U.	Standard Units

1.0 INTRODUCTION

This Pilot Study Report has been prepared for the Permeable Reactive Treatment (PeRT) Wall Pilot Study conducted at the Cape Canaveral Air Station (CCAS), Florida. The requirements for this work are specified in the December 1997 Statement of Work (SOW) for Delivery Order No. 0010 of Contract No. F41624-94-D-8048. The pilot study activities were conducted for the Air Force Center for Environmental Excellence (AFCEE). The purpose of this pilot study was to evaluate two new methods for emplacing reactive materials at depth.

The two methods of emplacement were demonstrated at the CCAS facility in a period between September and December of 1997. The pilot scale PeRT walls were installed to a depth of 45 feet below land surface within a chlorinated solvent plume. Following emplacement of the pilot scale PeRT walls, groundwater monitoring wells were installed in the vicinity to obtain water quality samples. Groundwater samples were collected during a period between February and November of 1998. The resulting data was used to evaluate the performance of the PeRT walls.

The remainder of this report is organized as follows:

Section 2: EXECUTIVE SUMMARY. This section presents a summary of the pilot study installation, monitoring and results.

Section 3: SITE BACKGROUND. This section presents a summary of site conditions, groundwater flow directions and quality prior to the installation of the pilot scale PeRT walls.

Section 4: PeRT WALL PILOT STUDY IMPLEMENTATION. This section presents the details of the overall installation effort, monitoring methodology and hydrogeologic results.

Section 5: REACTION MECHANISMS. This section presents a discussion of the reaction mechanisms and rates for destruction of chlorinated compounds using zero valent iron (Fe^{+0}).

Section 6: APPROACHES. This section presents a detailed discussion of the equipment, operations, results and lessons learned from each of the two emplacement technologies. This section also includes a conceptual design and cost estimate for a groundwater pump and treat system which would be equal in treatment capacity with the PeRT walls emplaced in this pilot study.

Section 7: CONCLUSIONS. This section presents a discussion of the conclusions reached during the pilot study and evaluation of groundwater data, including VOC degradation, useful lifetime of the PeRT walls, emplacement methods and comparison with groundwater pump and treat technology.

Section 8: RECOMMENDATIONS. This section presents recommendations for long-term monitoring and evaluation of the pilot scale system.

Section 9: REFERENCES. This section lists the references cited in the report.

2.0 EXECUTIVE SUMMARY

This report presents a description of the installation and monitoring results from pilot scale testing of Permeable Reactive Treatment (PeRT) walls at the Cape Canaveral Air Station (CCAS). The pilot testing was performed in the Industrial Area Operable Unit (OU) near Hangar K. The overall objective of this pilot study was to test two new methods for emplacing reactive materials at depth. The specific goals of the pilot study were to:

- Determine the extent of chlorinated volatile organic compound (VOC) degradation resulting from use of the PeRT walls;
- Determine the useful lifetime of the PeRT walls;
- Develop defensible data to illustrate the effectiveness of this technology in enhancing the remediation of contaminated soil and groundwater;
- Evaluate the effectiveness of emplacement technologies that can go to depths greater than 40 feet; and
- Compile data and evaluate of the applicability, cost, and performance of this technology, as it compares to traditional "pump and treat" methods of groundwater remediation.

Pilot scale PeRT walls were created using zero valent iron (Fe^{+0}) filings, installed in the ground. For purposes of comparing two installation methods, two sets of walls were installed. The first was installed by mandrel emplacement; the second by Jet Assisted Grouting (JAG). Historical data on groundwater flow and contaminant plume configuration were used to locate and orient the walls. An attempt was made to orient the walls perpendicular to groundwater flow. The contaminants of concern are trichloroethene (TCE), cis- and trans-1,2- dichloroethene (c/t-DCE), 1,1-dichloroethene (DCE), and vinyl chloride. The walls were installed in the uppermost aquifer, from a few feet below land surface (bls) to 45 feet bls.

Previous studies (Parsons ES, 1996a) divided the uppermost aquifer into three zones: shallow (from water table to 25 feet bls), intermediate (from 25 to 35 feet bls) and deep (from 35 to 50 feet bls). The highest concentrations of chlorinated compounds were detected in the deep zone (up to 696,100 μg/L total VOCs). The intermediate zone also contained measurable concentrations (up to 95,600 μg/L total VOCs). In most of the wells screened in the shallow zone, chlorinated compounds were detected at very low concentrations or not at all.

A field screening effort using direct push technology was initiated by the Air Force Center for Environmental Excellence (AFCEE) in April and July 1997. The purpose of this investigation was to collect additional data in the vicinity where the pilot scale PeRT walls were to be installed. The depth interval terminology used in this screening effort differs from the previous studies. The "shallow" samples were collected primarily from the interval of 32 to 35 feet bls. The exception is HK5S which was collected from 38 to 41 feet bls. The "deep" samples were collected from various depth intervals, ranging from 37 to 40 feet bls and 52 to 55 feet bls. The results of this screening effort indicated the following:

- The c/t-DCE concentrations in the "shallow" samples (generally 32 to 35 feet bls) were generally higher than the concentrations in the "deep" samples (ranging from 37 to 55 feet bls). The average c/t-DCE concentration in the "shallow" samples was approximately 93,000 µg/L. The average c/t-DCE concentration in the "deep" samples was approximately 31,000 µg/L.
- c/t-DCE was more prevalent in the "shallow" samples than in the "deep" samples. c/t-DCE was detected in 91% of the "shallow" samples (20 detections in 22 samples) and 29% of the "deep" samples (5 detections in 17 samples).
- The TCE concentrations in the "shallow" samples were generally higher than in the "deep" samples. The average TCE concentration in the "shallow" samples was approximately 3,900 µg/L. The average TCE concentration in the "deep" samples was approximately 700 µg/L.
- TCE was not prevalent in either the "shallow" or "deep" samples. TCE was detected in 9% of samples (2 detections in 22 samples) in the "shallow" and 12% of the "deep" samples (2 detections in 17 samples).
- Vinyl chloride was detected in similar magnitude and frequency in the "shallow" and "deep" samples.
- The distribution of c/t-DCE, TCE and vinyl chloride was not homogeneous.
- A semi-confining layer was present at approximately 45 feet bls.

The initial intention of the pilot study was to install the pilot scale PeRT walls to a depth of 60 feet bls. The presence of the semi-confining layer at 45 feet bls and the absence of contamination at deeper depths according to the field screening efforts made a revision necessary. It was decided that this semi-confining layer should not be breached, so the walls should not penetrate below 45 feet bls.

2.1 PILOT STUDY IMPLEMENTATION

Implementation of the pilot study proceeded in the following sequence:

1 Site Preparation
2 Mandrel wall installation
3 JAG wall installation
4 In-situ flow sensors installation
5 Monitoring well installation
6 Site restoration
7 Monitoring, sampling and analysis

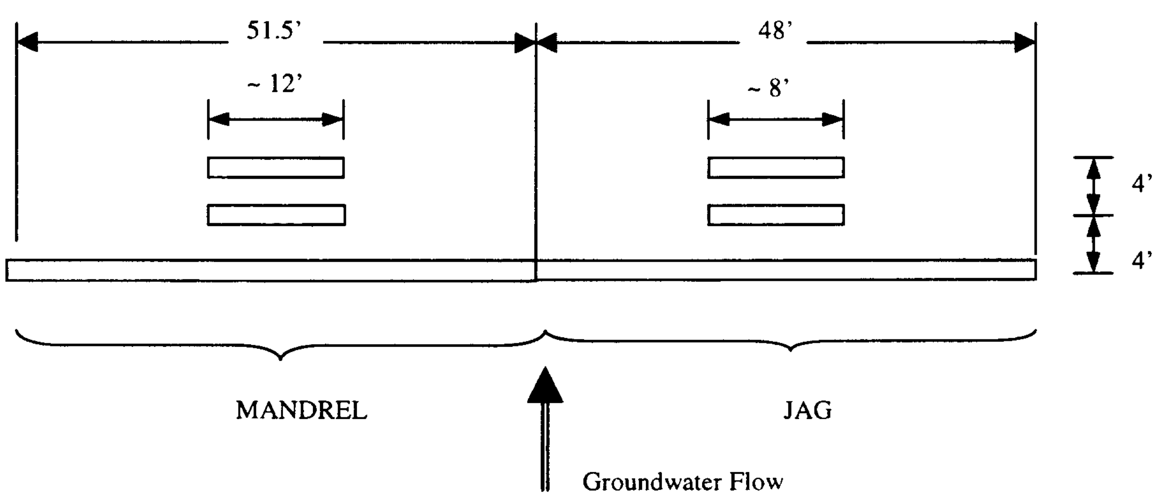
2.1.1 Site Preparation

Pavement in the area was removed and stockpiled. A trench was excavated along the centerline of the walls to clear utilities and stakes were placed to mark the wall terminations. Roll-off boxes and a portable tank were delivered and staged for collection of potentially contaminated Investigation Derived Waste (IDW).

2.1.2 PeRT Wall Installations

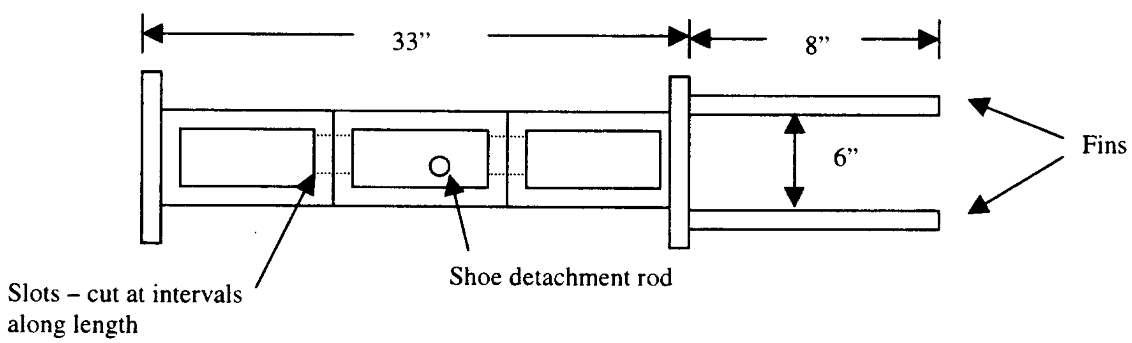
The mandrel wall segments were installed first, followed by the JAG wall segments. The layout for each installation was the same as shown in the TOP VIEW figure, below, the longest section was located up-gradient. Approximately 4 feet down-gradient of each of the longest section, a shorter section was installed. Approximately 4 feet down-gradient of each of the shorter sections, another short section was installed. The longest (up-gradient) segments of the mandrel and JAG walls overlap in the center to form a continuous treatment zone along the length of wall. The dimensions noted were measured after construction.

TOP VIEW



Slurry Systems, Inc. (SSI) of Gary, Indiana installed the pilot scale mandrel walls. The mandrel used in this project was adapted from the construction industry mandrels used to install wick drains. SSI fabricated the mandrel from square steel tubing, as shown in the PLAN VIEW figure below. The mandrel was designed to create a 60-foot deep iron panel of approximately 30-inches by 4 inches. Slots were cut through the interior sections of the square steel tubes at intervals along the bottom 12 feet to allow iron to flow between the internal tubing sections. The outside footprint is approximately 33-inches by 6-inches. Eight inch fins were welded near the bottom of the mandrel along one edge for alignment of the beam with the previously driven section:

PLAN VIEW



To create the continuous wall segments, a total of 32 panels were installed, overlapping approximately 4-inches with the adjoining panels. To install each panel, the mandrel was fitted with detachable driving shoes at the bottom (leading edge) of the mandrel. These shoes prevented soil from filling the void spaces in the tubes as the mandrel was driven into place with a 22-ton hammer. Once at depth, iron was poured into the hollow tubing sections and the shoe was knocked loose of the mandrel with the detachment rod. Additional iron was poured as the beam was withdrawn. An average of 6,000 pounds of iron was placed in each panel. The up-gradient wall segment is made from 22 overlapped panels and each down-gradient segment is made up of 5 overlapped panels.

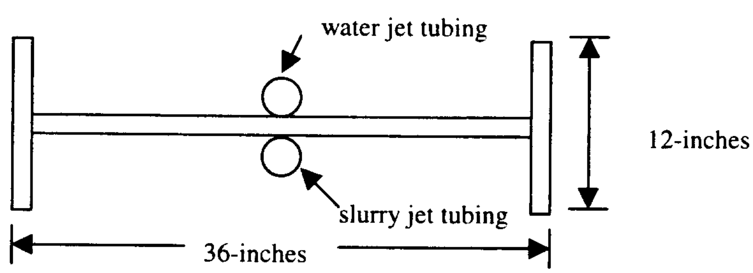
The iron installed in the mandrel wall segments was Peerless Cast Iron Aggregate 8/50 (100% passing an U.S. Standard No. 8 sieve and 90% to 100% retained on an U.S. Standard No. 50 sieve).

The JAG wall segments were installed by Geocisa/Geobase, under contract to Foremost Solutions. This installation technique required injection of a high viscosity iron slurry.

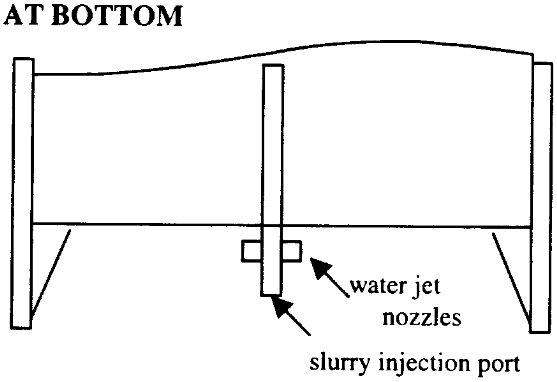
The guar gum was mixed with water in batches in a stirred open top tank to form 2 to 3% solutions. The guar gum solution was pumped first to a holding tank, then into a truck-mounted batch mixing plant. A positive displacement pump controlled the feed rate of guar gum to the batch mixing plant. The pump discharged the guar gum solution into an auger screw mixer. Iron filings were poured into the top of the batch mixing plant. An aggregate belt feed, synchronized to the guar gum pump, was used to add the iron filings to the screw auger mixer. In addition, an enzyme and a thickener were added with a metering pump. The screen mixer discharged into a grout pump hopper. The grout pump hopper fed a diesel powered grout pump with two 4-inch diameter swing-tube cylinders. The discharge was to hoses that fed the down-hole injection equipment.

The down-hole injection equipment used to install the wall segments consisted of a 48-foot long, 1-inch thick, 36-inch by 12-inch wide-flange steel beam with tubing welded to the web for water and iron slurry injection, shown below:

PLAN VIEW



SECTION VIEW AT BOTTOM



The beam was driven to depth with a 7-ton hammer. Water was jetted during driving to open a channel under the beam. The water jet assembly was attached to the leading edge of the beam web, with nozzles

oriented horizontally to direct spray at the inside surfaces of the flanges at either end. During driving, the water was injected at flows of up to 20-gpm and 6,000-psi pressure. The iron-slurry injection tubing was fitted with a bottom plug. A short steel rod suspended on a rope was used to knock the plug free when the beam was at depth. The amount of slurry pumped down-hole was measured by counting the number of strokes of the pump. The rate of slurry placement in the ground was controlled by the speed at which the beam was withdrawn.

The iron installed in the JAG wall segments was peerless P1 Cast Iron Aggregate, -16 to dust (100% passing a standard No. -16 sieve to dust).

The following presents a general comparison summary of the two wall installations:

PARAMETER	MANDREL	JAG
Installation Contractor	Slurry Systems, Inc	Geocisa/Geobase under contract to Foremost Solutions
Depth of wall emplaced	From ~1 to 45 feet bls	From ~3 to 45 feet bls
Total Length of 3 wall segments	75.5 feet	64 feet
Tons of iron emplaced	98 tons	93 tons pumped, approximately 83 tons emplaced and 10 tons spoils.
Type of Iron	Peerless 8/50	Peerless P1 (-16 to dust)
Date contractor arrived on site	29 Sept 1997	3 Nov 1997
Date set-up completed	4 Oct 1997	7 Nov 1997
Date testing began	Not Applicable	8 Nov 1997
Date testing completed	Not Applicable	12 Nov 1997
Date pilot installation began	6 Oct 1997	13 Nov 1997
Date pilot installation completed	15 Oct 1997	26 Nov 1997
Date demobilization completed	21 Oct 1997	1 Dec 1997
Total Installed Cost	$307,712	$306,538
Mobilization	$75,000	$40,000
Pre-Installation Testing	$0	$30,900
Cost per linear foot – excluding mobilization and testing	$3,082	$3,682
Cost per linear foot – including	$4,076	$4,790

PARAMETER	MANDREL	JAG
mobilization and testing		
Square feet installed	3,322	2,688
Cost per square foot – excluding mobilization and testing	$70	$88
Cost per square foot – including mobilization and testing	$93	$114

2.1.3 Flow Sensor Installation

Six in-situ groundwater flow sensors were installed to monitor the groundwater flow velocity and direction during the pilot study. Each flow sensor consists of a probe approximately 30 inches long and 2 inches in diameter. A heater inside of the probe heats groundwater as it flows past the probe. Each flow sensor probe has an array of temperature sensors on its surface. Groundwater is heated as it flows past the probe and these temperature sensors detect the temperature differences. The data is transmitted to a data logger. Software converts the temperature readings to groundwater velocity and direction components.

The flow sensors were installed by direct burial in the aquifer. A 3.25-inch hollow-stem auger was used to advance the 6 borings. Each flow sensor was installed at a depth of approximately 40 feet. An existing electrical unistrut was modified to mount a DC power converter (the power supply to the flow sensors) and data logger. Control and signal wires were run below-grade in conduit to the power supply and data logger.

2.1.4 Monitoring Well Installation

Sixteen pairs of monitoring wells were installed in vicinity of the pilot scale PeRT walls. Each pair consists of well screened from 15 to 20 feet bls (intermediate well) and a well screened from 35 to 40 feet bls (deep well).

2.1.5 Site Restoration

Site restoration included the following:

- Testing, removal and disposal of IDW generated during the JAG wall and monitoring well installations and monitoring well development;
- Clean-up of iron spilled during installation;
- Replacement of asphalt in parking area; and
- Seeding and placing sod in disturbed grass areas.

2.2 MONITORING PROGRAM

Key performance indicators were monitored over a 10-month period following installation of the pilot scale PeRT wall sections. These indicators included:

- Analysis of VOCs in groundwater on a quarterly basis to determine the effectiveness of the wall and the extent of VOC degradation;
- Monthly field measurements of groundwater pH, electrical conductivity, turbidity, hardness, oxidation-reduction potential, alkalinity, and concentrations of total Iron, Iron II valent (Fe^{+2}), and sulfate;
- Monthly water levels in surrounding monitoring wells to determine effect of wall on groundwater flow; and
- Monthly evaluation of in-situ flow sensor data.

During the pilot test, the water table ranged from 3.78 to 6.25 feet below ground surface at the monitoring well measuring points (2.66 to 4.95 feet above mean sea level [msl]).

Monitoring results indicate the following general trends for both sets of pilot test PeRT walls in the deep wells (screened 35 to 40 feet bls):

1. The concentrations of cis-1,2 dichloroethene (c-DCE), trans-1,2 dichloroethene (t-DCE) and DCE generally decrease as groundwater moves through the wall segments;
2. The concentration of vinyl chloride generally increases; and
3. The average influent concentration (total VOCs) reaching the main reactive wall increased by 35 percent during the monitoring period.

The same general trends of vinyl chloride increasing and other chlorinated solvent concentrations decreasing as water flows across wall segments were noted in wells screened in the intermediate zone.

The concentrations upgradient and downgradient are significantly lower in this zone than in the deep zone.

Groundwater flow in the PeRT Wall/Hangar K area is generally to the west-northwest. Horizontal flow gradients and velocities vary across the site, with the highest velocities through the PeRT Wall. In the overall Hangar K area, the deep aquifer horizontal flow gradients and velocities are one-fifth the values through the PeRT Wall, and slightly less than this value for the aquifer zone below the PeRT Wall.

It appears that the head differences between intermediate (from 15 to 20 feet bls) and deep (from 35 to 40 feet bls) PeRT Wall wells are very small, indicating little, if any downward flow gradient. Hydraulic sections indicate that there is as much as 0.6 feet of downward head from the deep PERT wall wells to the aquifer zone below the wall. This was the case before and following the wall installations.

2.3 CONCLUSIONS

The two emplacement techniques, mandrel and JAG, were successfully demonstrated to emplace reactive materials at depths exceeding 40 feet.

The monitoring results collected during the first year of operation were insufficient to determine the effectiveness of the PeRT walls on groundwater restoration. Two of the reasons for inconclusive results include the slow rate of groundwater flow and the high variability of the influent chlorinated VOC concentrations. During installation of the monitoring wells, it was noted that the soils at 35 to 40 feet bls in this area are silty to clayey sands. High organic vapor analyzer (OVA) readings (between 100 and 450 ppm) were noted on soil samples from these depth intervals. It is therefore likely that the chlorinated solvents at this depth are adsorbed onto the soils. As water flows through a wall segment and is treated, additional chlorinated VOCs may desorb from the soil down-gradient of the wall. With the slow rate of groundwater flow in the area, this could continue for a prolonged period of time. Therefore, additional monitoring is recommended to determine if further degradation of the chlorinated VOCs occur with time.

The potentiometric map created with the final round (November 1998) of water level measurements for the deep zone suggest that mounding may be starting to develop at the wall. This mound, however, is in the range of 0.04 feet and may be totally attributable to uncertainties in survey and water-level measurement. The tolerances for the survey readings is +/- 0.01 foot and the accuracy of any water-level

measurement may be in the range of +/- 0.05 feet. However, this possible mounding trend should be investigated in future water-level data analysis.

Conservative estimates of mineral precipitation suggest that over a 100 year period the following are maximum percentages of the available pore space that could be filled: carbonates, 20%; sulfides, 6%; and hydroxides, 17%. If these rates of mineral formation persist, porosity in the wall would decrease to zero in about 400 years and groundwater flow may be significantly diverted earlier. These estimates are preliminary and should be reevaluated after another year of groundwater monitoring.

An estimate comparing capital and operating and maintenance (O&M) with conventional groundwater "pump and treat" systems indicates that the savings in O&M cost associated with the PeRT Walls could off-set the higher capital cost in less than 4 years.

3.0 SITE BACKGROUND

The CCAS occupies approximately 25 square miles on a barrier island along the east coast of Florida in Brevard County (Figure 3-1). The facility contains assembly and launch facilities for missiles and space vehicles. The island is bordered by the Atlantic Ocean to the east, the Banana River to the west, and a man made shipping channel to the south. The John F. Kennedy Space Center adjoins the CCAS to the north.

Hangar K is located within the Industrial Area OU near the center of the CCAS. Hangar K is in the center of fabrication shops area and has therefore been the center of chemical usage for many years (Parsons ES, 1996a). The location of the Industrial Area OU is shown in Figure 3-2. The PeRT Wall Pilot Study was conducted in the Hangar K Area as shown on Figure 3-3.

3.1 REGIONAL GEOLOGY

The uppermost aquifer extends to a depth of approximately 100 feet based upon regional literature. This aquifer consists of fine to coarse grained sands interbedded with silt and clay to the explored depth of 52 feet. A discontinuous soil layer occurs at a depth of approximately 50 feet in several areas of the CCAS.

The Hawthorn Formation underlies the uppermost aquifer and consists of sandy phosphatic clay with light green to greenish-gray sandy soil and beds of phosphatic sandy limestone. Regional literature indicates that the Hawthorn Formation occurs at a depth of approximately 100 feet but site-specific data is not available.

According to published geologic reports, the Hawthorn Formation is underlain by the Tertiary Limestone Aquifer (Florida Aquifer) which occurs at depths ranging from 100 to 200 feet.

3.2 PREVIOUS STUDIES

VOCs that were detected during previous investigations in the Hangar K area consisted primarily of chlorinated compounds including TCE, the cis- and trans- isomers of 1,2-DCE, 1,1 dichloroethane (DCA), dichlorobenzene (DCB), and vinyl chloride. The areas with the highest concentrations of these compounds were to the north, northeast, and northwest of the Hangar K building. Concentrations were highest in monitoring wells screened into the deep zone (approximately 35 to 50 feet bls) and intermediate zone (approximately 25 to 35 feet bls) of the uppermost aquifer. Total VOCs were detected in deep wells IC0025 and IC0026 at levels of 269,100 μg/L and 47,000 μg/L, respectively. VOCs have

also been detected in intermediate wells INDAMWI04 and 1724MWD02 at levels of 95,600 µg/L and 42,730 µg/L, respectively (See Table 3-1). Most shallow wells screened from approximately 5 to 25 feet bls either had no VOCs or very low concentrations. Groundwater plume maps illustrate the total historical VOC concentration in the intermediate zone (Figure 3-4) and the deep zone (Figure 3-5) of the uppermost aquifer.

Initial investigations at Hangar K were done by GPI Environmental, Inc. for General Dynamics Space Division during a 1990 Comprehensive Environmental Audit to address sites leased by General Dynamics from the USAF. As part of the audit, forty wells were installed and sampled in the area of Hangars J and K. Results of the sampling indicated the presence of a groundwater contaminant plume with VOCs, including TCE, c/t-DCE, vinyl chloride, DCA, and DCB. Most of the contamination was detected north and west of Hangar K with vinyl chloride concentrations of 8,300 µg/L and 4,900 µg/L observed in samples from deep wells IC0025 and IC0026, respectively.

In 1994, several of the monitoring wells were sampled by Radian Corporation for Martin Marietta Astronautics. The additional sampling indicated that the maximum concentrations of TCE, vinyl chloride, and c/t-DCE were 62,000 µg/L, 3,900 µg/L, and 130,000 µg/L, respectively in IC0025 and 2,600, 10,000 and 3,900 µg/L, respectively in IC0026.

Sampling of these wells again in 1995 indicated an increase of TCE to 94,000 µg/L and 24,000 µg/L, respectively, and c/t DCE to 170,000 µg/L and 23,000 µg/L, respectively.

Additional groundwater quality data were obtained from selected monitoring wells in the Hangar K area by Parsons ES in February and March 1997. The highest total VOC concentrations were detected in wells INDA-MW117 (72,800 µg/L), located adjacent to IC0026, and INDA-MWD16 (63,130 µg/L), located adjacent to IC0025. The data obtained during this sampling effort are included in Table 3-1.

A field screening effort utilizing direct push techniques was initiated in April 1997 under the direction of AFCEE. Data were collected to find an area near Hangar K with high chlorinated VOC concentrations. Water quality data obtained during the field screening effort using field analysis procedures are summarized in Table 3-2. Samples were obtained from "shallow" (generally 32 to 35 feet bls) and "deep" (generally 47 to 55 feet). Four direct push well points (HK5S, HK10D, and HK14D and HK19D) were screened between the intermediate and deep direct push sample points at depths between 38 and 44 feet bls. The locations of the direct push sample points and total VOC concentrations detected are shown

on Figures 3-6 and 3-7. Note that the "shallow" designation corresponds to the intermediate zone of the upper most aquifer. The data from the direct push samples indicated the following:

- The c/t-DCE concentrations in the "shallow" samples (generally 32 to 35 feet bls) were typically higher than the concentrations in the "deep" samples. The average c/t-DCE concentration in the "shallow" samples was approximately 93,000 μg/L. The average c/t-DCE concentration in the "deep" samples was approximately 31,000 μg/L.
- c/t-DCE was more prevalent in the "shallow" than in the "deep" samples. c/t-DCE was detected in 91% of the "shallow" samples (20 detections in 22 samples) and 29% of the "deep" samples (5 detections in 17 samples).
- The TCE concentrations in the "shallow" samples were generally higher than in the "deep" samples. The average TCE concentration in the "shallow" samples was approximately 3,900 μg/L. The average TCE concentration in the "deep" samples was approximately 700 μg/L.
- TCE was not prevalent in either the "shallow" or "deep" samples. TCE was detected in 9% of the "shallow" samples (2 detections in 22 samples) and 12% of the "deep" samples (2 detections in 17 samples).
- Vinyl chloride was detected in similar magnitude and frequency in the "shallow" and "deep" samples.
- The distribution of c/t-DCE, TCE and vinyl chloride was not homogeneous.
- A semi-confining layer was present at approximately 45 feet bls.

3.3 GROUNDWATER OCCURENCE

Shallow groundwater occurs under water table conditions at the site. A groundwater divide occurs near the site causing radial groundwater flowing to the north, northeast, and northwest of the pilot study area. Maps illustrating the groundwater potentiometric surface in April 1996 for the shallow and deep zones of the uppermost aquifer are shown as Figures 3-8 and 3-9. Monitor well construction details are presented in Appendix A. This historical information indicates that prior to installation of the PeRT wall segments the general groundwater flow directions in the area were to the northwest. The estimated groundwater flow velocities were 0.05 feet/day in the deep zone and 0.5 feet/day in the intermediate zone.

3.4 HISTORICAL BACKGROUND OF PeRT WALL TECHNOLOGY

The PeRT wall technology is being advanced as an alternative to conventional groundwater extraction and treatment ("Pump and treat") systems. "Pump and treat" systems involve extracting contaminated groundwater from the ground where it can be treated above ground in wastewater treatment processes. Some groundwater treatment systems for chlorinated VOCs involve phase separation of the contaminants from the groundwater, such as air stripping which transfers the contaminants to vapor and adsorption which transfers the contaminants to a solid substrate. When the contaminants are transferred to vapor phase, emission control equipment (typically activated carbon or thermal oxidation) may be needed. When adsorbents are used, testing must be performed to determine when to change or regenerate the adsorbent media. Regeneration can be performed either in-place (as with regenerative carbon beds) or the material may be shipped off-site for regeneration. Vertical extraction wells may be installed to collect groundwater or horizontal interceptor systems may also be installed. When contamination is shallow, collection trenches may be installed to intercept groundwater flow. For deeper contamination, horizontal wells can be installed to perform the same function as the interceptor trenches. Pumping must be continued for a sufficient time for contaminants that are adsorbed onto the soil to be released to the groundwater and then collected by the extraction well or interceptor trench systems, which may required many years.

PeRT walls are located and installed to perform the same function as the interceptor system in a groundwater collection system. Rather than installing collection piping, sand and filter fabric, Fe^{+0} filings are placed in the interceptor system. For this technology, the groundwater is not pumped out of the ground, but is treated as it flows through the Fe^{+0}. Because the PeRT walls are a passive form of remediation, the operational cost is minimal, although the capital cost may exceed that of a "pump-and-treat" system. A PeRT wall's design purpose is to convert the chlorinated VOCs to nontoxic compounds without removing them from the ground.

The first PeRT walls probably used anoxic limestone to treat acid mine drainage. In 1991, researchers at the University of Waterloo first demonstrated the use of Fe^{+0} in a PeRT wall to treat chlorinated VOCs at the Canadian Forces Base Borden. The success of this demonstration project prompted a widespread interest in PeRT wall technology that persists today. The first commercial PeRT wall with Fe^{+0} was installed at an industrial site in Sunnyvale, California in January 1995. The Sunnyvale PeRT wall has been successfully treating chlorinated VOCs since its installation. Currently, there are at least 13 commercial PeRT walls using Fe^{+0} to degrade chlorinated VOCs and at least 13 additional pilot PeRT

walls that have been installed to determine site-specific effectiveness. Table 3-3 summarizes the status of commercial and pilot scale installations.

Most PeRT walls have been installed in trenches supported by sheet piling. A rectangular shaped box is formed with vertical sheet piling and then the native soil within the box is removed. Driven culverts are sometime used in lieu of the sheet piling. After filling the void with Fe^{+0}, the sheet piling is removed to allow groundwater to flow through the reactive medium. The funnel and gate designs listed in Table 3-3 were installed using this method. This type of installation is limited based on soil types, to maximum depths of about 40 feet. Since many plumes are deeper, the AFCEE has an interest in adapting construction techniques that are capable of emplacing Fe^{+0} deeper in the ground.

The mandrel used in this project was adapted from the construction industry. Mandrels are commonly used to install wick drains in water-saturated mill tailings. The only use of a mandrel to install reactive materials was in the Lasagna system at Paducah, Kentucky (Table 3-3), where electrodes and Fe^{+0} were emplaced a clay-rich zone contaminated with chlorinated VOCs. Contaminated water was moved through the reactive zone by electroosmosis. The mandrel used at the CCAS PeRT wall was larger than the Lasagna mandrel and those used for installing wick drains so that a relatively thick zone of Fe^{+0} could be installed with fewer insertions. The CCAS project is the first to use a mandrel to install a Fe^{+0} PeRT wall in a flowing groundwater system. The JAG technology has not previously been used to install iron.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

MEMORANDUM FOR Defense Technical Information Center
Attn: DTIC-OMI (Input Support Branch)
Suite 0944
8725 John J. Kingman Road
Ft. Belvoir, VA 22060-6218

FROM: AFCEE/ERT, 3207 North Road, Brooks AFB, TX 78235-5361

SUBJECT: Documents for input into DTIC

Enclosed are documents for input into DTIC. These documents do not need to be returned to us. Attached is a listing of the documents. For all these documents, distribution is unlimited. If you need additional information please call me at DSN 240-4353, (210) 536-4353.

JERRY E. HANSEN
Environmental Engineer

HQ AFCEE/ERT Documents, 21 Jan. 00

1.Draft, Pilot Study Report Permeable Reactive Treatment (PeRT), Wall Pilot Study, Cape Canaveral Air Station, FL, Nov 1999

2 Final, Remediation by Natural Attenuation Treatability Study for Site FT004, Randolph, AFB, TX, Dec 1999

3. Final, Intrinsic Remediation Treatability Study for the Upper Naknek Site (SS-12), King Salmon Airport, AK, Oct 1999

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

MEMORANDUM FOR Defense Technical Information Center
Attn: DTIC-OMI (Input Support Branch)
Suite 0944
8725 John J. Kingman Road
Ft. Belvoir, VA 22060-6218

FROM: AFCEE/ERT, 3207 North Road, Brooks AFB, TX 78235-5361

SUBJECT: Documents for input into DTIC

Enclosed are documents for input into DTIC. These documents do not need to be returned to us. Attached is a listing of the documents. For all these documents, distribution is unlimited. If you need additional information please call me at DSN 240-4353, (210) 536-4353.

JERRY E. HANSEN
Environmental Engineer

HQ AFCEE/ERT Documents, 21 Jan. 00

1.Final, Demonstration of Remediation by Natural Attenuation for Groundwater (Site FTA-2), Tinker AFB, OK, Dec 1999

2 Final, Remediation by Natural Attenuation Treatability Study for Building 301, Offutt AFB, NE, Oct 1999

3. Final, Remediation by Natural Attenuation Treatability Study for Operable Unit 1, Altus, AFB, OK, Dec 1999

TABLE 3-1
HISTORICAL CHLORINATED VOC DATA

Well ID	Date Sampled	TCE (µg/L)	DCA (µg/L)	c/t-DCE (µg/L)	1,1,1-Trichloroethane (µg/L)	Vinyl Chloride (µg/L)	Total Chlorinated VOCs (µg/L)
Deep Wells							
1724MWD01	1/25/94	NA	NA	4,244	NA	NA	4,244
1724MWD01	12/31/95	ND	NA	2,200 J	NA	ND	2,200
1724MWD01	April 1996	ND	NA	2,200	NA	ND	2,237
1724MWD01	Mar 1997	28	NA	4,755	NA	8.1	4,791.1
IC0024	6/21/90	ND	NA	ND	NA	ND	0
IC0024	6/3/94	ND	NA	2	NA	ND	2
IC0024	12/13/95	ND	NA	5.2	NA	ND	5.2
IC0024	April 1996	ND	NA	6	NA	ND	6
IC0025	6/19/90	780	420	2,200	NA	8,300	11,700
IC0025	6/7/94	62,000	NA	130,000	NA	3,600	195,600
IC0025	12/12/95	94,000	NA	170,000	NA	5,100 F	269,100
IC0025	April 1996	10,270	NA	17,380	NA	3,220	33,144
IC0026	6/20/90	11	NA	7	NA	4,900	4,918
IC0026	6/6/94	2,600	NA	10,000	310	3,900	16,810
IC0026	12/12/95	24,000	NA	23,000	NA	ND	47,000
IC0026	April 1996	3,250	NA	8,274	NA	5,310	17,420
INDABOSA1	1/10/96	ND	NA	ND	NA	ND	ND
INDABOSA1	April 1996	ND	NA	ND	NA	ND	ND
INDAMWD03	April 1996	ND	NA	ND	NA	ND	ND
INDAMWD04	April 1996	87	NA	2,386	NA	120	2,679
INDAMWD04	Feb 1997	ND	NA	ND	NA	1.9	1.9
INDAMWD16	April 1996	6,150	NA	20,060	NA	3,370	31,861
INDAMWD16	Feb 1997	31,430	NA	27,720	NA	3,980	63,130
INDAMWD16*	April 1997	217,000	NA	49,000	NA	NA	266,000
INDAMWDD16*	April 1997	94,000	NA	3,000	NA	NA	97,000
INDAMWD17	April 1996	12	NA	7,922	NA	6,720	15,601
INDAMWD17	Feb 1997	ND	NA	12,200	NA	7,100	19,300
INDAMWD22	Feb 1997	ND	NA	8.6	NA	10	18.6

TABLE 3-1 (Concluded)
HISTORICAL CHLORINATED VOC DATA

Well ID	Date Sampled	TCE (µg/L)	DCA (µg/L)	c/t-DCE (µg/L)	1,1,1-Trichloroethane (µg/L)	Vinyl Chloride (µg/L)	Total Chlorinated VOCs (µg/L)
<u>Intermediate Wells</u>							
1724MWD02	12/20/94	ND	NA	15,000	NA	ND	15,000
1724MWD02	12/13/95	20,000	NA	22,000 J	NA	ND	42,700
1724MWD02	April 1996	20,000	NA	22,000	NA	ND	42,730
1724MWD02	Mar 1997	21,720	NA	15,430	NA	72	37,222
INDAMWI04	April 1996	ND	NA	86,900	NA	5,800	95,600
INDAMWI04	Feb 1997	170	NA	20,520	NA	3,620	24,310
INDAMWI16	April 1996	ND	NA	1,236	NA	380	1,692
INDAMWI16	Feb 1997	16	NA	936	NA	370	1,322
INDAMWI16*	April 1997	<1,000	NA	<1,000	NA	NA	<1,000
INDAMWI17	April 1996	6,900	NA	11,780	NA	940	21,054
INDAMWI17	Feb 1997	27,000	NA	45,700	NA	170	72,870
INDAMWI22	Feb 1977	ND	NA	11,810	NA	2,750	14,560

Notes:
NA - Data Not Available
ND - Not Detected; below instrument detection limit

* - Based on April 1997 Field Lab Data

TABLE 3-2
DIRECT PUSH SCREENING DATA SUMMARY[1]

Direct Push Well Point ID	Northing	Easting	Top of Casing Elevation (msl)	Screened Interval (feet bls)	Screened Interval (msl)	c/t-DCE[1] Concentration (ug/L)	TCE[1] Concentration (ug/L)	Total c/t-DCE & TCE Concentration (ug/L)	Vinyl Chloride Concentration (ug/L)
HK1S	1511810	790823	8.55	32 to 35	-23.5 to -26.5	86000/88000	<1000	88000	NT
HK2S	1511782	790801	8.46	32 to 35	-23.5 to -26.5	70000	<1000	70000	NT
HK3S	1511746	790780	8.40	32 to 35	-23.6 to -26.6	10000	<1000	10000	NT
HK4S	1511802	790770	8.88	32 to 35	-23.1 to -26.1	102000	<1000	102000	NT
HK5S	1511810	790817	8.72	38 to 41	-29.3 to -32.3	66000/70000	154000/131000	201000	NT
HK6S	1511790	790858	8.14	32 to 35	-23.9 to -26.9	78000/72000	3000/3000	75000	NT
HK7S	1511716	790893	9.43	32 to 35	-22.6 to -25.6	183000	<1000	183000	NT
HK8S	1511837	790840	8.84	32 to 35	-23.2 to -26.2	27000	<1000	27000	NT
HK9S	1511859	790855	8.91	32 to 35	-23.1 to -26.1	107000/100000	<1000	100000	NT
HK10S	1511836	790790	9.10	32 to 35	-22.9 to -25.9	56000	<1000	56000	NT
HK11S	1511821	790744	9.18	32 to 35	-22.8 to -25.8	4000	<1000	4000	NT
HK12S	1511848	790765	9.23	32 to 35	-22.8 to -25.8	127000	<1000	127000	NT
HK13S	1511878	790786	9.27	32 to 35	-22.7 to -25.7	192000	<1000	192000	NT
HK14S	1511861	790809	9.22	32 to 35	-22.8 to -25.8	190000	<1000	190000	NT
HK15S	1511714	790754	8.26	32 to 35	-23.7 to -26.7	ND	ND	ND	ND
HK16S	1511892	790881	8.64	32 to 35	-23.4 to -26.4	73000	ND	73000	ND
HK17S	1511758	790836	7.89	32 to 35	-24.1 to -27.1	29000	ND	29000	ND
HK18S	1511926	790830	9.19	32 to 35	-22.8 to -25.8	282000	ND	282000	ND
HK19S	1511954	790789	8.8	32 to 35	-23.2 to -26.2	167000	ND	167000	ND
HK20S	1512012	790818	8.54	32 to 35	-23.5 to -26.5	196000	ND	196000	ND
HK21S	1511844	790712	8.79	32 to 35	-23.2 to -26.2	2400	ND	2400	12000
HK22S	1512021	790347	9.46	32 to 35	-22.5 to -25.5	ND	ND	ND	ND
Average[2] of concentrations from the intermediate zone						92,905	3,934	98,836	1,500
Maximum of concentrations from the intermediate zone						282,000	154,000	282,000	12,000

TABLE 3-2 (Concluded)
DIRECT PUSH SCREENING DATA SUMMARY[1]

Direct Push Well Point ID	Northing	Easting	Top of Casing Elevation (msl)	Screened Interval (feet bls)	Screened Interval (msl)	c/t-DCE[1] Concentration (ug/L)	TCE[1] Concentration (ug/L)	Total c/t-DCE & TCE Concentration (ug/L)	Vinyl Chloride Concentration (ug/L)
HK1D*				47 to 50		<1000	<1000	<1000	NT
HK2D	1511781	790801	8.36	47 to 50	-38.6 to -41.6	<1000	<1000	<1000	NT
HK3D	1511745	790779	8.37	47 to 50	-38.6 to -41.6	<1000	<1000	<1000	NT
HK4D*				47 to 50		<1000	<1000	<1000	NT
HK5D	1511808	790821	8.57	52 to 55	-43.4 to -46.4	<1000	<1000	<1000	NT
HK7D	1511714	790894	9.36	52 to 55	-42.6 to -45.6	<1000	<1000	<1000	NT
HK10D	1511835	790790	9.13	38 to 41	-28.9 to -31.9	115000	8000	123000	NT
HK14D	1511860	790809	9.18	41 to 44	-31.8 to -34.8	62000	4000	66000	NT
HK15D	1511713	790753	8.30	48 to 51	-39.7 to -42.7	ND	ND	ND	0.09
HK16D	1511892	790881	8.64	48 to 51	-39.4 to -42.4	ND	ND	ND	ND
HK17D	1511758	790836	8.03	47 to 50	-39.0 to -42.0	ND	ND	ND	ND
HK18D	1511927	790830	9.18	37 to 40	-27.8 to -30.8	66000	ND	66000	ND
HK19D	1511955	790790	8.85	38 to 41	-29.2 to -32.2	269000	ND	269000	ND
HK20D	1512012	790818	8.58	48 to 51	-39.4 to -42.4	ND	ND	ND	ND
HK21D	1511845	790713	8.72	48 to 51	-39.3 to -42.3	ND	ND	ND	ND
HK22D	1512022	790346	9.41	48 to 51	-38.6 to -41.6	ND	ND	ND	ND
HK23D	1511718	790746	8.35			14000	ND	14000	10000
Average[2] of concentrations from the deep zone						30,941	706	31,647	1,111
Maximum of concentrations from the deep zone						269,000	8,000	269,000	10,000

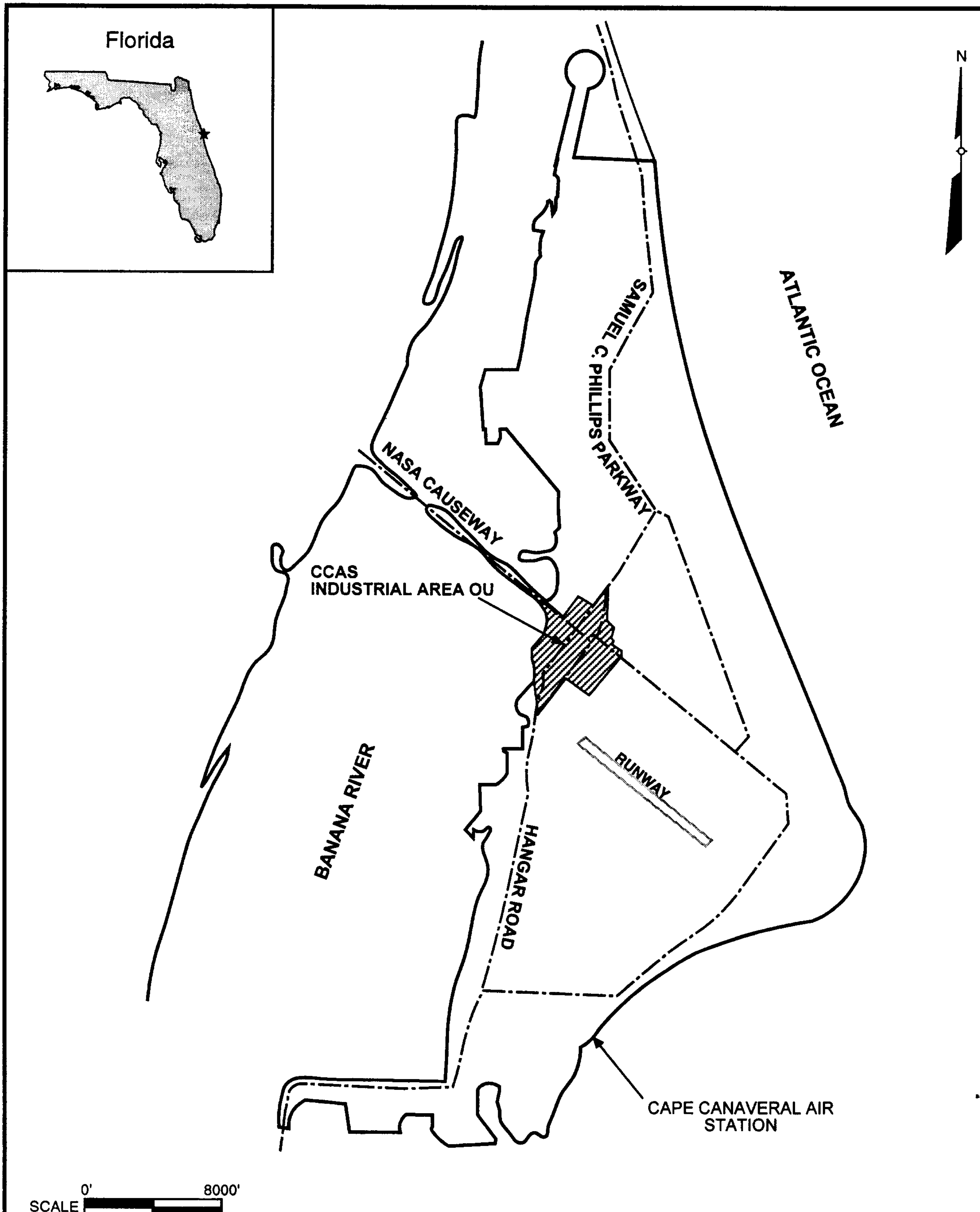
Notes:
* Not Completed as a Well Point
ND – Not Detected at instrument detection level
NT – Not Tested
1 Where two values are presented, separated by a "/" symbol, the second number in the sequence is a duplicate sample.
2 For averaging purposes, not detected values were considered zero and not tested values were not included. For samples where duplicates were recorded, the average of the duplicate values was used.

TABLE 3-3
SUMMARY OF PeRT WALLS USING FE^{+0} TO TREAT CHORINATED VOCs

No.	Country/State/ Prov	Site	Contaminants	Install Date	Status	Depth	Reactant	Type	Designation
1	Alabama	Maxwell AFB	cVOC	1998	Operating	75 ft	FE^{+0}	Frac/Jet	Pilot
2	California	Alameda	cVOC	12/96	Operating		FE^{+0}	F&G	Pilot
3	California	Moffat Field	cVOC	4/96	Operating	20 ft	FE^{+0}	F&G	Pilot
4	California	Mountain View	cVOC	9/95	Operating	20 ft	FE^{+0}	Trench	Commercial
5	California	Newbury Park	cVOC		Operating	87 ft	FE^{+0}foam	Fracing	Pilot
6	California	Sunnyvale	cVOC	1/95	Operating	30 ft	FE^{+0}	F&G	Commercial
7	Colorado	Federal Center	cVOC	10/96	Operating	25 ft	FE^{+0}	F&G	Commercial
8	Colorado	Lowry AFB	cVOC		Operating	25 ft	FE^{+0}	F&G	Pilot
9	Colorado	Rocky Flats	cVOC, U	9/98	Operating	5 ft	FE^{+0}	Cannister	Commercial
10	Delaware	Dover AFB	cVOC		Operating		FE^{+0}	F&G	Pilot
11	Florida	Cape Canaveral	cVOC	10/97	Operating	45 ft	FE^{+0}	Mandrel	Pilot
12	Florida	Cape Canaveral	cVOC	11/97	Operating	45 ft	FE^{+0}	JAG	Pilot
13	Florida	Cape Kennedy	cVOC		Operating		FE^{+0}/Sonic	Deep Mixing	Pilot
14	Ireland	Belfast	cVOC	12/95	Operating	40 ft	FE^{+0}	Cannister	Commercial
15	Kansas	Coffeyville	cVOC	1/96	Operating	28 ft	FE^{+0}	F&G	Commercial
16	Kentucky	Paducah	cVOC	1995	Operating		FE^{+0}/+	Lasagna	Pilot
17	Massachusetts	MMR	cVOC	1998	Operating	120 ft	FE^{+0}	Fracing	Pilot
18	New Hampshire	Summersworth	cVOC	1997	Operating		FE^{+0}	F&G	Pilot
19	New Jersey	Caldwell Trucking	cVOC	3/98	Operating		FE^{+0}	Fracing	Commercial
20	New Jersey	Fairfield	cVOC	9/98	Operating	25 ft	FE^{+0}/Sand	Trench	Commercial
21	New Mexico	Sandia	Cr/TCE/CCl4	1997	Completed	8 ft	FE^{+0}/GAC/ +	Jetting	Demonstration
22	New York	Sherburne	cVOC	12/97	Operating	15 ft	FE^{+0}	F&G	Commercial
23	North Carolina	Elizabeth City	cVOC, Cr	6/96	Operating	26 ft	FE^{+0}	Cont. trencher	Commercial
24	Ontario	Borden CFB	cVOC	1993	Completed	8 ft	FE^{+0}/Sand	F&G	Pilot
25	Oregon	Unnamed	cVOC	1998	Operating	30 ft	FE^{+0}	Cont. Trencher	Commercial
26	South Carolina	SRS-Siphon	TCE	7/97	Operating	15 ft	FE^{+0}	Geosiphon	Pilot
27	South Carolina	Manning	cVOC	1998	Operating	29 ft	FE^{+0}	Cont Trencher	Commercial

Notes:

FE^{+0} = zero-valent iron, F&G = funnel and gate, Sonic = sonication, + = other materials, Cont = continuous, jet = jetting, JAG = jet assisted grouting



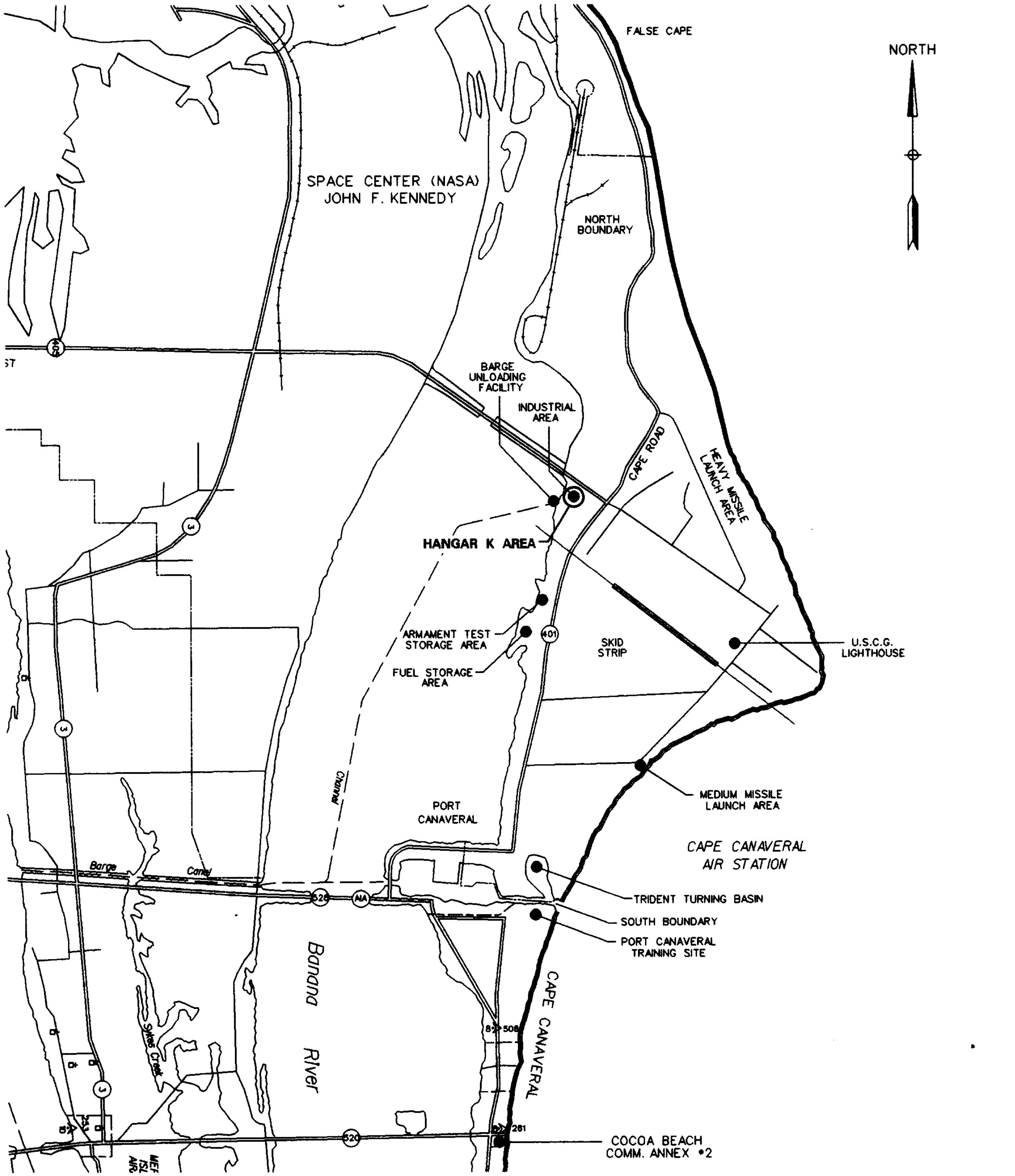
RUST

Rust Environment & Infrastructure

FIGURE 3-1
LOCATION OF CAPE CANAVERAL
AIR STATION

CAPE CANAVERAL AIR STATION, FLORIDA
Project No. 29515

Zip D.14/39748/CapeCanaveral/F_1-1Loc.Ind.Area.fh5



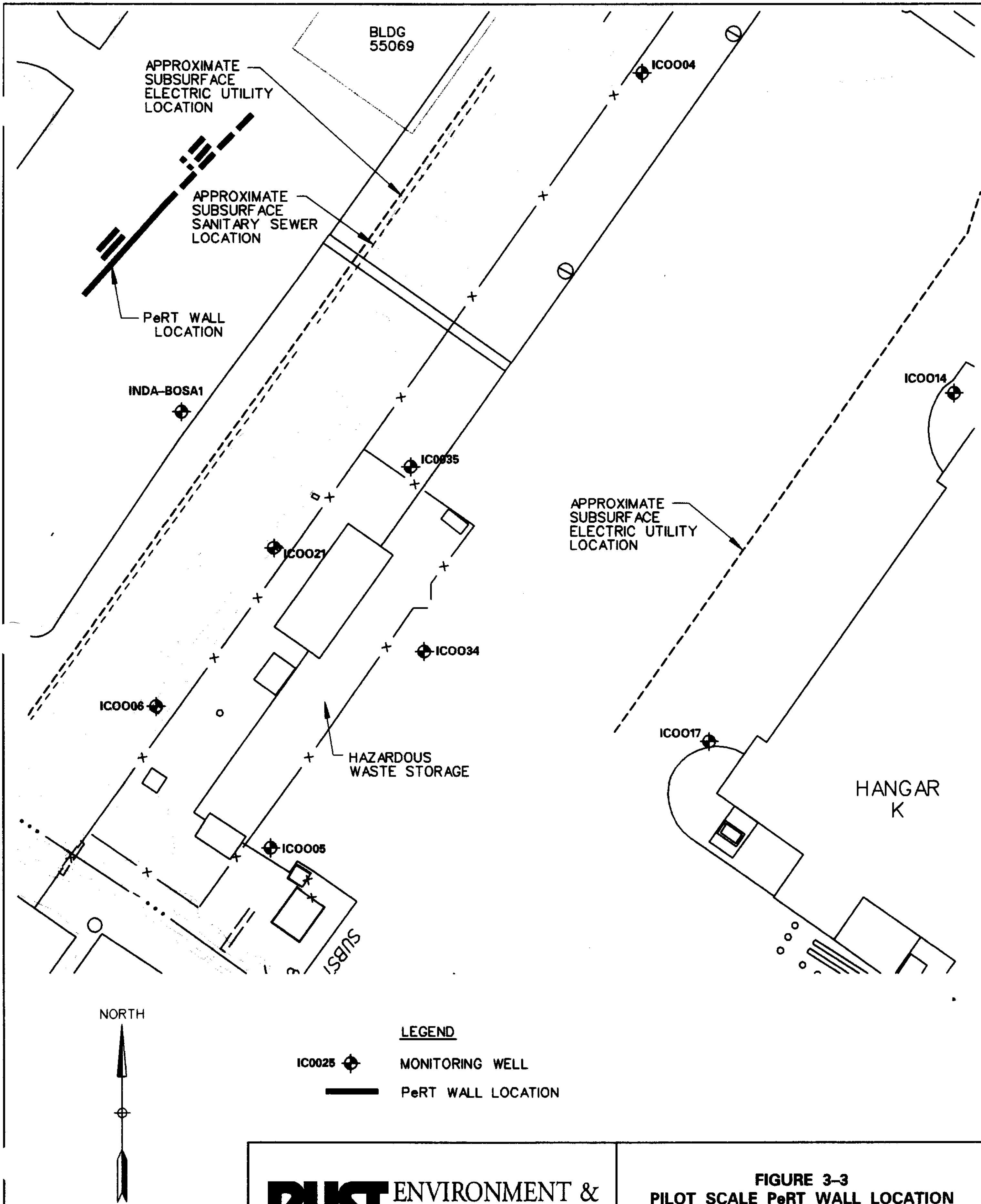
0 5000 10000 15000
SCALE IN FEET

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3–2
LOCATION OF HANGAR K AND INDUSTRIAL AREA

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515.000

N:\39748\9748WPF2.DGN

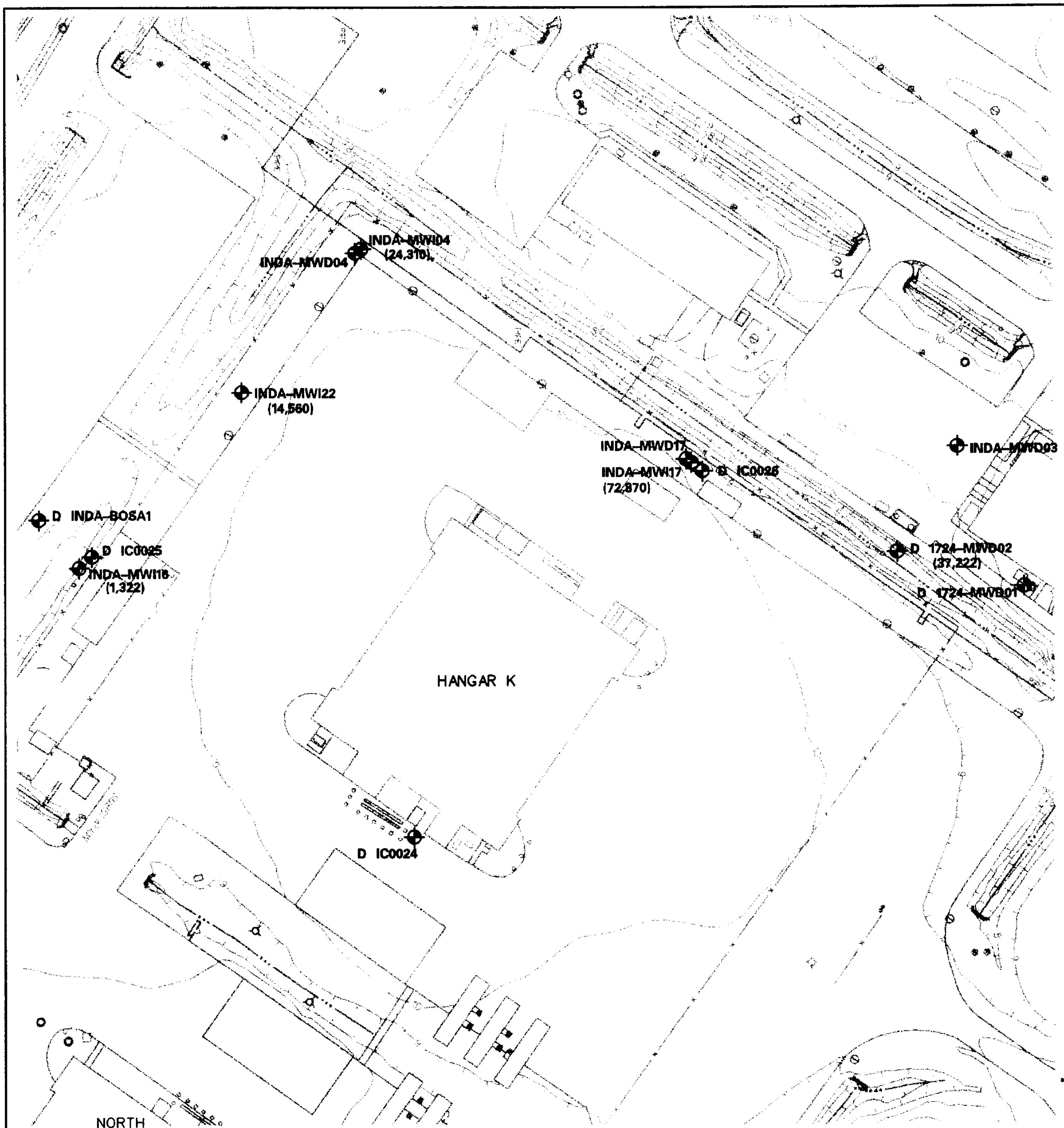


RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3-3
PILOT SCALE PeRT WALL LOCATION

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748PT10.dgn



LEGEND

MONITORING WELL

(1322) TOTAL CHLORINATED VOLATILE ORGANICS (µg/l), BASED ON DATA OBTAINED IN FEBRUARY AND MARCH 1997

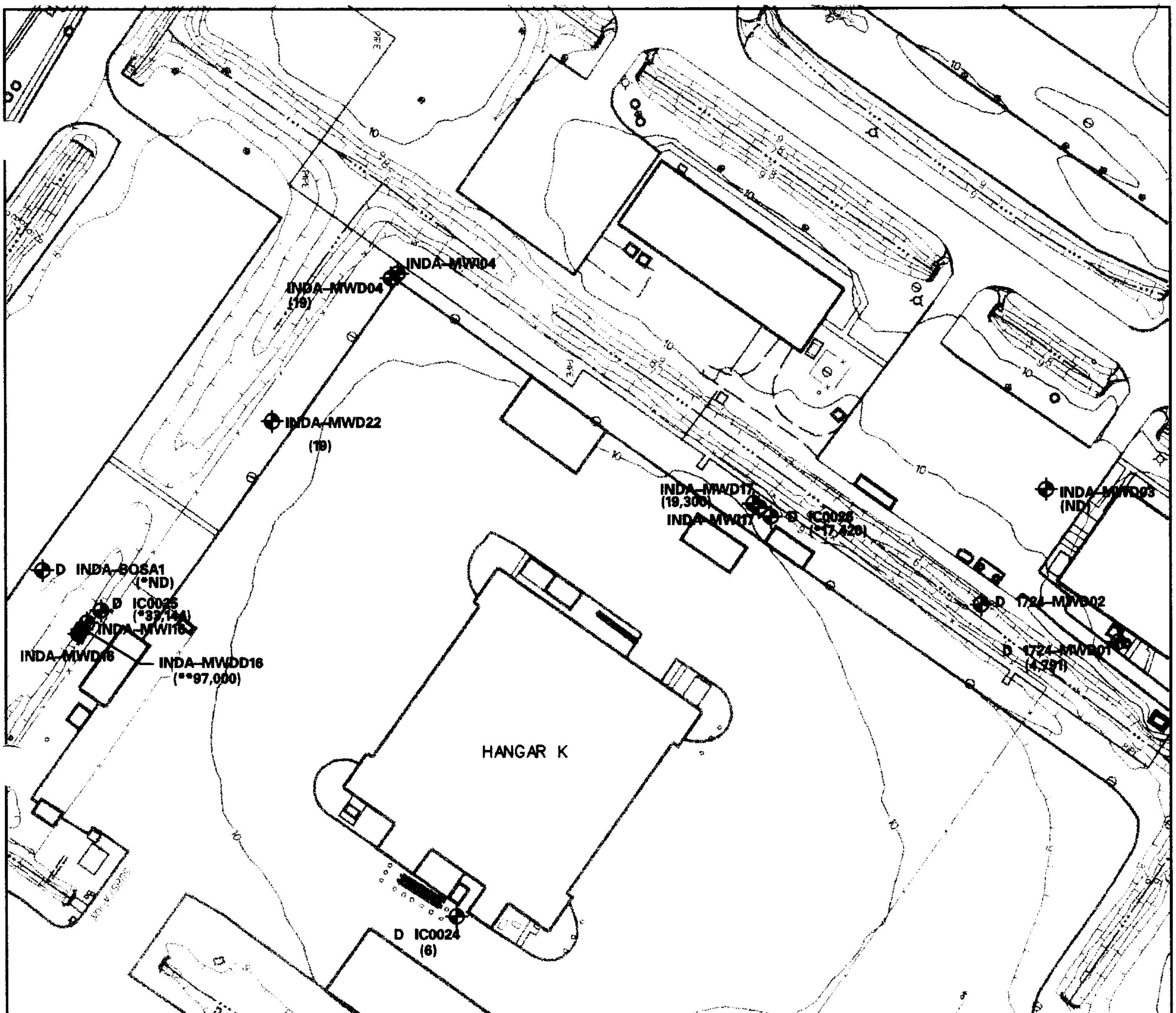
NOTE: GROUNDWATER FLOWS GENERALLY RADIALLY OUTWARD FROM HANGAR K. SEE FIGURES 3-9 AND 3-10.

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3-4
TOTAL CHLORINATED VOC CONCENTRATIONS IN THE INTERMEDIATE ZONE OF THE UPPERMOST AQUIFER

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748WP05.DGN



LEGEND

MONITORING WELL

(**97,000) TOTAL DCE AND TCE CONCENTRATION (μg/l) BASED ON APRIL 1997 FIELD LAB DATA

(*17420) TOTAL CHLORINATED VOLATILE ORGANICS (μg/l), BASED ON DATA OBTAINED IN DECEMBER 1995 OR APRIL 1996

(1900) TOTAL CHLORINATED VOLATILE ORGANICS (μg/l), BASED ON DATA OBTAINED IN FEBUARY AND MARCH 1997

NOTE: GROUNDWATER FLOWS GENERALLY RADIALLY OUTWARD FROM HANGAR K, SEE FIGURES 3-9 AND 3-10.

NORTH

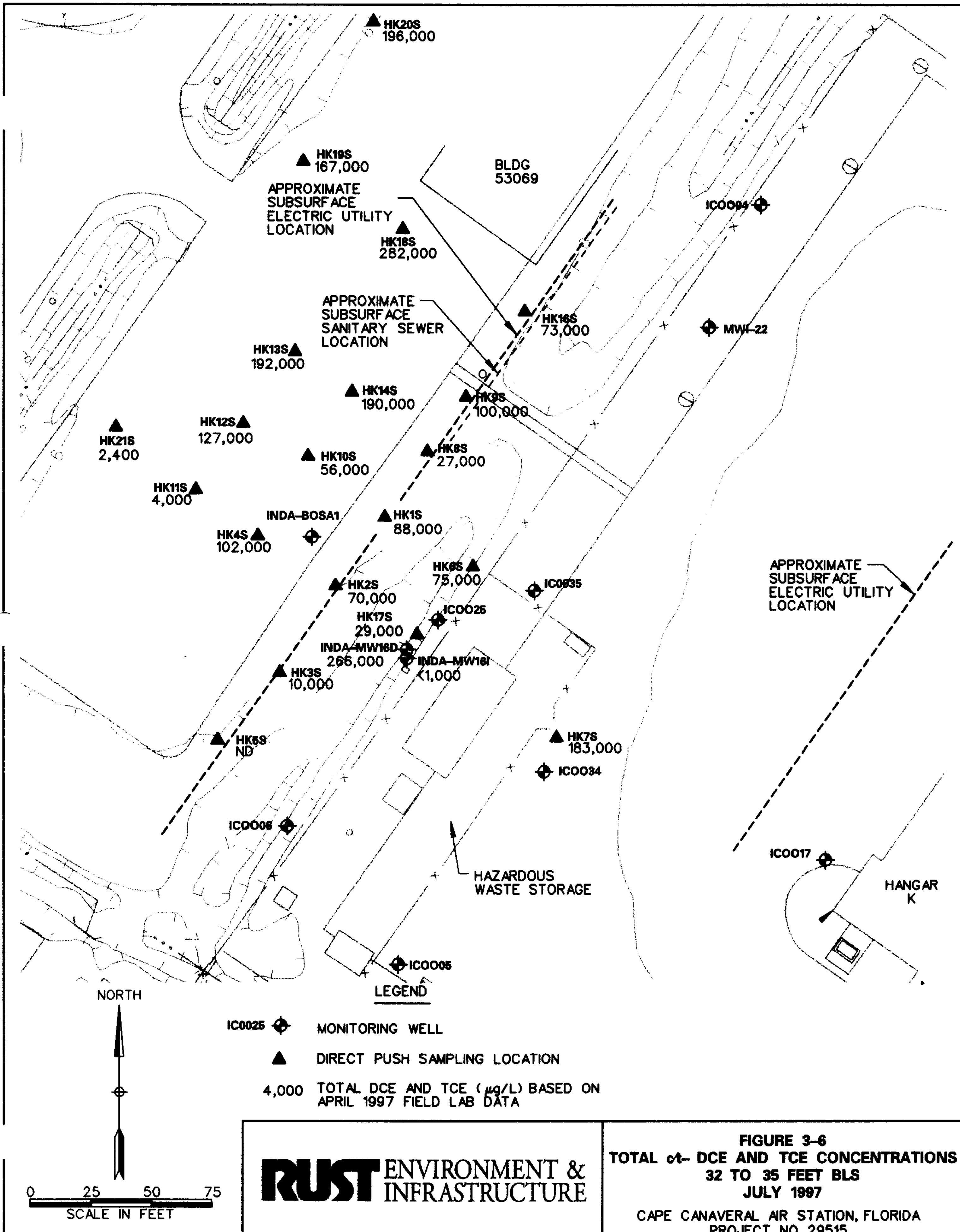
0 50 100 150
SCALE IN FEET

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3-5
TOTAL CHLORINATED VOC CONCENTRATIONS IN THE DEEP ZONE OF THE UPPERMOST AQUIFER

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748WP40.DGN

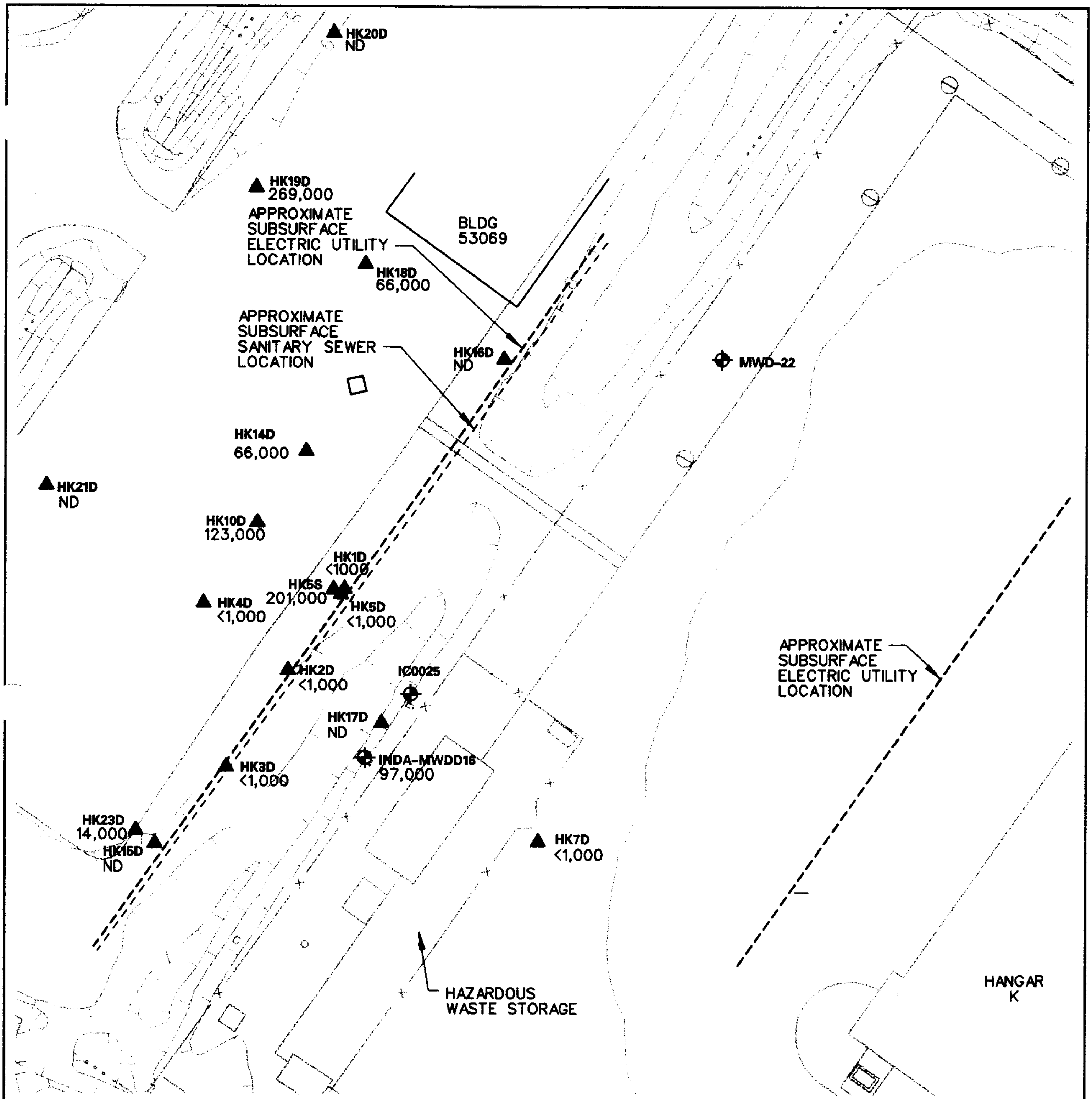


RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3-6
TOTAL c/t- DCE AND TCE CONCENTRATIONS
32 TO 35 FEET BLS
JULY 1997

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748FT27.DGN



NORTH

LEGEND

MONITORING WELL

DIRECT PUSH SAMPLING LOCATION

97,000 TOTAL DCE AND TCE (μg/L) BASED ON APRIL 1997 FIELD LAB DATA

NOTES:
1. SEE TABLE 3-2 FOR SAMPLE DEPTHS.
2. WELL HK22D IS APROXIMATELY 450' NW OF HK19D AND IS ND.

0 25 50 75
SCALE IN FEET

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3-7
TOTAL ct- DCE AND TCE CONCENTRATIONS
DEEP ZONE BELOW 38 FEET
JULY 1997

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748PT28.DGN

NORTH

0 200 400 600
SCALE IN FEET

LEGEND

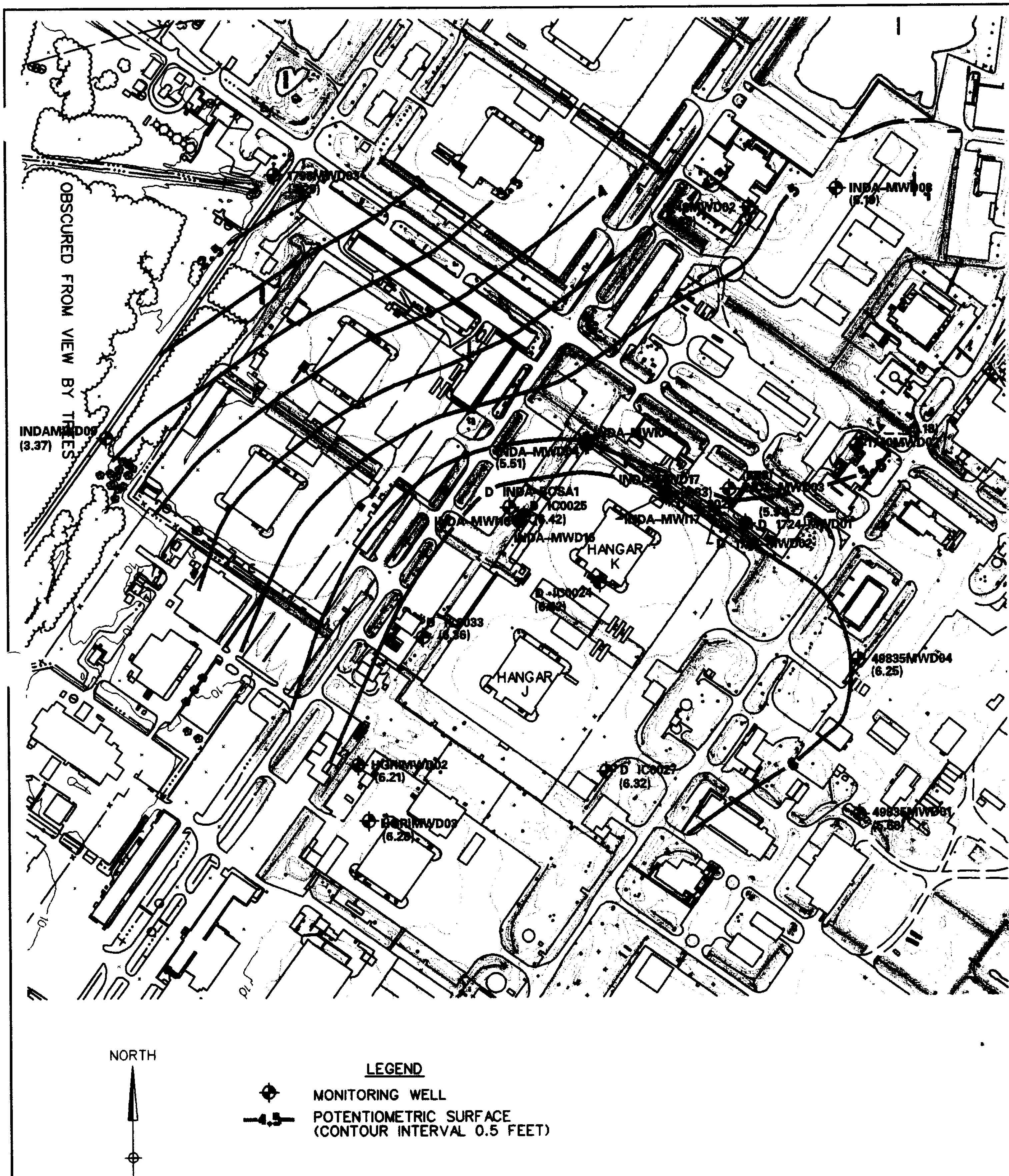
MONITORING WELL

POTENTIOMETRIC SURFACE (CONTOUR INTERVAL 0.25 FEET)

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3-8
POTENTIOMETRIC SURFACE MAP: SHALLOW ZONE OF THE UPPERMOST AQUIFER (APRIL 4, 1996)
CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748PS4S.DGN



RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 3-9
POTENTIOMETRIC SURFACE MAP:
DEEP ZONE OF THE
UPPERMOST AQUIFER (APRIL 4, 1996)
CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748PS4D.DGN

4.0 PeRT WALL PILOT STUDY IMPLEMENTATION

4.1 PILOT STUDY OBJECTIVES

The overall objective of this pilot study was to pilot test two new methods for emplacing reactive material at depth.

The specific goals of the pilot study were to:

1. Determine the extent of chlorinated VOC degradation resulting from use of the PeRT walls;
2. Determine the useful lifetime of the PeRT walls;
3. Develop defensible data to illustrate the effectiveness of this technology in enhancing the remediation of contaminated soil and groundwater;
4. Evaluate the effectiveness of emplacement technologies that can go to depths greater than 40 feet; and
5. Compile data and evaluate of the applicability, cost, and performance of this technology, as it compares to traditional "pump and treat" methods of groundwater remediation.

Initially, the intention of the pilot study was to install the PeRT walls to a depth of 60 feet bls. When the semi-confining layer was discovered, it was decided that the maximum depth of each wall and well should not penetrate the semi-confining layer. The maximum installation depth was therefore restricted to 45 feet bls.

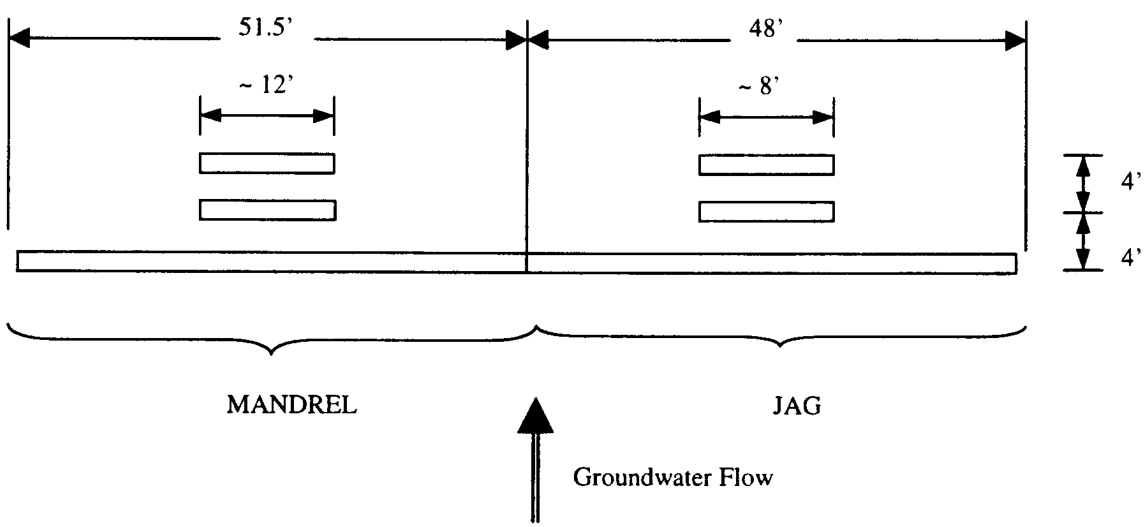
Two sets of pilot scale PeRT walls were installed in the vicinity of Hangar K (Figure 3-3). The walls were installed using two techniques: mandrel and JAG emplacement. The mandrel wall segments were installed first, followed by the JAG wall segments. The layout for each installation was the same, as shown on the PLAN VIEW figure below: the longest (approximately 50-foot long) section was located up-gradient. Approximately 4 feet down-gradient of each of the longest section, a shorter (approximately 10-foot long) section was installed. Approximately 4 feet down-gradient of each of the shorter sections, another short (approximately 10-foot long) section was installed. The longest (up-gradient) segments of the mandrel and JAG walls overlap in the center to form a continuous treatment zone along the length of wall.

The 100-foot total length of the two overlapped pilot scale PeRT Walls was thought to be adequate for a Pilot Study for evaluating the emplacement methodologies. Since the PeRT walls are not keyed into any

confining soils on either end, it was important that the installation process did not reduce the permeability of the soils in the vicinity of the emplacement. Reducing the permeability of soils in the vicinity of the PeRT walls could divert the flow of groundwater such that it did not pass through the PeRT walls. Since both emplacement methods used in this pilot study displace soils into the formation (see Section 6 for detailed information on emplacement methods), it was decided that the best way to limit compaction of soils was to limit the thickness of the PeRT walls. For this reason, the thickness of the walls was limited to 4-inches.

Preliminary estimates of required VOC retention time in the reactive iron indicated that an approximately one-foot thickness of iron would be required for complete destruction of the VOC contaminants in the groundwater. Since the thin-wall technology to be tested would result in a four-inch thick wall of iron, it would take three segments to total the necessary 12 inches of iron thickness. Using concentration data along the anticipated flow line through the entire thickness of reactive iron will permit an evaluation of the degradation rate. For this reason, 3 of the 4-inch walls were installed in such a configuration that a concentration profile could be developed as groundwater flowed between wall segments. The PeRT wall segments were placed 4-feet apart to allow the installation of groundwater monitoring wells between the segments.

PLAN VIEW



Historical groundwater levels and concentration data were used to locate the wall in an area of high VOC concentrations, roughly perpendicular to groundwater flow. Following installation of the PeRT walls, monitoring wells and flow sensors were installed in the vicinity and sampled for approximately one year

to evaluate PeRT wall performance. Figure 4-1 shows a generalized layout of the wall sections, flow sensor and monitoring well placement. Section 6 of this report provides details on the methods of installation. Two parameters that were considered critical in the installation were that the wall thickness be nearly uniformly 4-inches thick and that the wall be continuously overlapped from top to bottom of installed panel. In the mandrel installation, the thickness installed was determined by the set thickness of the mandrel opening (approximately 4-inches). The thickness of wall installed by JAG emplacement equipment was determined by varying injection rates and pressures in a test area on-site prior to installation of the pilot scale PeRT walls. For both installations, alignment was measured using a 4-foot level. The tolerance was determined to be ± 7-inches of deviation at depth. This would be sufficient to ensure at least a 1-inch overlap at the bottom of the panel. This means that in the four feet measured by the level, the maximum allowable deviation would be ½-inch from level.

In order to measure groundwater flow velocities and directions, six flow sensors, manufactured by Hydrotechnics, Inc., were installed at locations shown on Figure 4-1 at a depth of approximately 40 feet bls. The flow sensors are coupled to 2-inch poly vinyl chloride (PVC) pipe (which acts as a conduit for power and control cables), and are buried directly into soil. Each flow sensor consists of a probe approximately 30 inches long and 2 inches diameter. An 80 -Watt heater inside of the probe heats groundwater as it flows past the buried flow sensor. Each flow sensor has an array of 30 temperature sensors (thermistors) on its surface. The heater increases the temperature of the groundwater flowing past the probe and the temperature sensors detect the resulting gradients in groundwater temperature. Temperature data at each probe is transmitted to a data logger that averages data over a half-hour period. Software developed by Hydrotechnics, HTFLOW©, converts the temperature results to vertical and horizontal components of groundwater flow velocity and provides the azimuth direction (in degrees from North). The thermistors are calibrated prior to shipment such that the measured differences between temperature sensors are accurate to within ± 0.01 °C.

Sixteen pairs of monitoring wells were installed at locations shown on Figure 4-1. Each pair consists of well screened in the intermediate zone of the uppermost aquifer (intermediate well) and a well screened in the deep zone of the upper most aquifer (deep well). The intermediate wells are approximately 20 feet deep and screened from approximately 15 to 20 feet bls. The deep wells are approximately 40 feet deep and screened from approximately 35 to 40 feet bls.

4.2 INSTALLATION

The sequence for construction of the pilot study was as follows:

1 Site Preparation
2 Mandrel wall installation
3 JAG wall installation
4 In-situ flow sensors installation
5 Monitoring well installation
6 Site restoration

Site Preparation

The areas to be disturbed during the installation were laid out and marked. CCAS Base personnel located utilities within the marked areas. An electrical line and a sewer pipe were found in the grass area where the in-situ flow sensor power and control cables were to be placed for the pilot study. Figure 4-2 shows the location of utilities in the vicinity of work.

Barricades were set up around the work area to prevent traffic from entering the affected area of parking lot. Approximately 1,000 square yards of asphalt were removed for installation of the walls, wells and flow sensor wiring. Kemron Environmental Services performed the site preparation work. A trench was excavated along the centerline of the walls to clear utilities and stakes were placed to mark the wall terminations.

Roll-off boxes were staged for collection of solid IDW. Initially drums were used to contain liquid IDW, then as the volume of liquid exceeded estimates, a tank was rented for collection of liquid IDW. Roll-off boxes, transportation and disposal of solid IDW was performed by Fenn-Vac. The portable tank was rented from Baker Tanks. Non-hazardous waste liquid IDW was transported to the Base water treatment facility. Hazardous waste liquid IDW was transferred into drums and transported by Intersol for treatment at Fisher Industrial Service.

Mandrel Wall Installation

The pilot scale mandrel walls were emplaced by SSI. The location of the Mandrel wall installation is shown on Figure 4-3. Figure 4-4 presents a cross section through the three wall segments. Details regarding the emplacement methods are presented in Section 6.1. The furthest up gradient (longest) wall section is 51 ½ feet long, 4-inches wide and 45 feet deep (extending from approximately 1-foot bls to 45-feet bls). Approximately 4 feet down-gradient of the longest wall, a 12-feet, 1-inch long, 4-inch wide, 45 feet deep wall is installed parallel to the first. Approximately 8 feet down-gradient of the longest wall, a third wall, 11-feet, 11-inches long, 4 inch wide and 45 feet deep wall was installed parallel to the first two.

Jet Assisted Grouting Wall Installation

The pilot scale JAG walls were emplaced by Geocisa/Geobase, under contract to Foremost Solutions. The location of the JAG wall installation is shown on Figure 4-5. Figure 4-6 presents a cross section through the three wall segments. Details regarding the emplacement methods are presented in Section 6.2. The furthest up gradient (longest) wall section is approximately 48 feet long, 4-inches wide and 45 feet deep (extending from 3 to 5 feet bls to 45 feet bls). Approximately 4 feet down-gradient of the longest wall, an 8-foot long, 4-inch wide and 45-foot deep wall is installed parallel to the first. Approximately 8 feet down-gradient of the longest wall, a third wall, 8-foot long, 4 inches wide and 45 feet deep wall was installed parallel to the first two.

In-Situ Flow Sensor Installation

Drilling and electrical installation services for the flow sensor installation were provided by U.S. Environmental. The flow sensor manufacturer, Hydrotechnics, was on-site to oversee the installation of the sensors and to ensure proper alignment. For each flow sensor installation, a 3.25-inch internal diameter (I.D.) hollow stem auger was advanced to a depth of approximately 40 feet. The flow sensors were installed through the center of the hollow stem auger. PVC pipe was coupled to the flow sensors as a conduit to contain the power cable to the heater and control wires from the temperature sensors. The 3.25-inch auger was selected because it was the smallest diameter auger that would allow installation of the probe. Hydrotechnics determined the initial probe alignment relative to true North. This measurement is reported to be accurate to within ± 10° from North (Ballard, 1996). Wiring was run below grade in conduits to the power supply and data logger. The heater power supply and the data

logger were installed at an existing power supply at the location shown on Figure 4-7. Figure 4-8 shows the electrical installation at the power supply and data logger.

Monitoring well installation

Monitoring wells were installed by U.S. Environmental at locations shown in Figure 4-1. Drilling was performed using a rotary flight auger. The auger was a 4.25-inch ID hollow stem auger. This auger produces an 8-inch diameter boring.

Construction details for each well are summarized in Table 4-1. Each well was constructed of 1¼-inch PVC, expanded to 2 inches at the surface to allow for installation of a locking cap. Well screens consist of 1¼ -inch continuous slot wire wrapped, schedule 40 PVC, 5-foot long sections, total screen length of 5-foot. The filter pack was 20/30-gradation silica sand, emplaced from the bottom up through the hollow stem augers. Bentonite pellets were placed above the filter pack and cement grout was installed through the augers. Well construction details are shown in Figure 4-9 and 4-10 for a typical well pair. Monitoring well development records are shown as Figure 4-11 and Figure 4-12 for a typical well pair. As these wells were installed in a parking lot, all wells were terminated below grade and finished at the surface with a 8-inch traffic rated manhole set into a concrete pad. Monitoring well identification tags were installed in the concrete pads.

Soil lithology was logged by a Rust geologist registered in the State of Florida. Representative logs are included in Appendix B.

Site Restoration

Site restoration work was performed by Kemron. The trench was backfilled with soil. The sub-base and asphalt were replaced in the parking lot and the parking area was resurfaced and striped. Sod or seed was placed in grass areas disturbed by the installation work.

4.3 MONITORING

Key performance indicators were monitored over a 10-month period following installation of the pilot scale PeRT wall sections. These indicators included water quality, water levels and flow data. The following tasks were used to obtain these indicators:

- Collection and analyses of groundwater samples for analysis of VOCs on a quarterly basis to determine the effectiveness of the wall to the extent of VOC degradation;
- Monthly field measurements of groundwater pH, electrical conductivity, turbidity, hardness, oxidation-reduction potential, alkalinity, and concentrations of total iron, Fe^{+2}, and sulfate;
- Monthly water levels in surrounding monitoring wells to determine effect of wall on groundwater flow; and
- Monthly evaluation of in-situ flow sensor data.

4.3.1 Groundwater VOC Analyses

Samples were collected from the pilot study monitoring wells quarterly for analysis of VOCs by EPA Method SW-846 8260B. For the first and third quarters, all of the wells were sampled and analyzed. For the second and fourth quarters, only the deep wells were sampled and analyzed. Results are presented in Appendix C. Four chlorinated VOCs were consistently detected during this monitoring: vinyl chloride, t-DCE, c-DCE and DCE. The data for each of the detected parameters is summarized in table form as follows:

- Table 4-2: Vinyl Chloride Summary
- Table 4-3: trans-1,2-Dichloroethene Summary
- Table 4-4: cis –1,2-Dichloroethene Summary
- Table 4-5: 1,1-Dichloroethene Summary
- Table 4-6: Data Qualifier Explanations

4.3.2 Field Chemistry Measurements

Samples were collected monthly from each monitoring well. Field instruments and colorometric test kits were used to obtain the water chemistry data presented in Table 4-7. In August 1998, two sampling events were performed. A full round of field parameters was measured for the samples collected for the first sampling event, the week of August 10, 1998. This round of sampling coincided with the third round of groundwater VOC sample collection. Due to weather related delays, Federal Express did not deliver the samples to the laboratory for three days. When the samples were received at the laboratory, the temperatures were above the range acceptable for VOC analyses. Therefore, a second sampling event was implemented the week of August 24, 1998. For this event, only parameters needed to measure purging were measured and recorded.

A summary of each parameter is presented in tabular form, with averages and standard deviations by well and by month. These data are presented as follows:

- Table 4-8: Water Temperature Summary
- Table 4-9: pH Summary
- Table 4-10: Electrical Conductivity Summary
- Table 4-11: Turbidity Summary
- Table 4-12: Total Iron Concentration Summary
- Table 4-13: Fe^{+2} Concentration Summary
- Table 4-14: Hardness Concentration Summary
- Table 4-15: Oxidation- Reduction Potential Summary
- Table 4-16: Sulfate Concentration Summary
- Table 4-17: Dissolved Oxygen Concentration Summary
- Table 4-18: Alkalinity Concentration Summary
- Table 4-19: Explosimeter Reading Summary

4.3.3 Water Level Measurements

Water levels were measured monthly in the pilot study monitoring wells and surrounding wells. Table 4-20 presents the results of the water level measurements. The data from 8/7/97 were collected prior to installation of the PeRT walls and pilot study monitoring wells.

4.3.4 Flow Sensor Data

Data from the flow sensors were downloaded monthly during well sampling. Monthly results are presented in Table 4-21 with the calculated error root mean square (ERMS). For two of the sensors (installed at locations PRT 03 and PRT 16) the ERMS was above 0.3 for all readings, thus the data is not considered valid. Results are summarized by flow sensor location as follows:

- Table 4-22: Results for Flow Sensor at Location PRT 03
- Table 4-23: Results for Flow Sensor at Location PRT 05
- Table 4-24: Results for Flow Sensor at Location PRT 10
- Table 4-25: Results for Flow Sensor at Location PRT 15

- Table 4-26: Results for Flow Sensor at Location PRT 16
- Table 4-27: Results for Flow Sensor at Location PRT 21

The ERMS value is a comparison of the actual data with the results from previously generated theoretical velocity profiles. The lower the ERMS value, the better the actual data fits a theoretical profile. This is calculated based on instantaneous readings, and is not a comparison of changes in flow over time. The changes in flow over time are reported as a ± amount. High ERMS values indicate that the actual data does not match a single velocity profile. The probes measure a temperature profile over a 1-cubic meter area. The software will average the data to perform the curve fit. If the velocity is different at the bottom of the probe than at the top, or on either side of the probe, the ERMS value will be high.

Possible causes of high ERMS values in this installation include:

- The lithologies may differ from bottom to top of probe, creating different velocities;
- The probe may have been installed close enough to the wall(s) that the thermal properties of the wall(s) are creating the heterogeneity in temperature profile; or
- There may not have been good "collapse" of soils into the hole augered for installation of the probes.

4.4 HYDROGEOLOGY

4.4.1 PeRT Wall Area Stratigraphy

The 18 borings advanced to 40-foot depths around the PeRT Wall (Deep monitoring wells at locations HGRK-PRTMW -01, -02, -03, -04, -05, -07, -09, -11, -12, -13, -14, -15, -16, -17, -18, -20 and flow sensors at locations PRT -10 and -21) provided detailed sub-surface stratigraphic descriptions. The geologic materials observed were similar to those seen throughout the Hangar K area. In the immediate vicinity of the PeRT wall the subsurface stratigraphy consists of very fine to coarse grained sands with silt and clay, and sandy clay and silt. Figure 4-13 is a geologic section, oriented from southwest to northeast, along the PeRT Wall. Geologic sections perpendicular to 4-13 are presented on Figures 4-4 and 4-6. As shown in these figures, there is no consistent layering of these materials with shallow depth across the site. For the most part, PeRT wall wells are screened in fine-grained silty sand with some wells screened partially in fine to medium sand.

Boring logs (BOSA01) and cone penetrometer technology (CPT) logs (1 to 7HKF) of nearby, deeper wells indicates that a clay layer occurs at a depth of 40 to 50 feet. These CPT borings are all on the

upgradient (southeast) side of the PeRT wall and BOSA01 on the downgradient side. It is not known if this clay layer is continuous across the Hangar K area.

4.4.2 Aquifer Zones Monitored

Previous studies (Parsons ES, 1996a) divided the aquifer into three zones. Figure 4-14 shows the wells by screen elevations (this figure is intended for grouping of well screens by elevation and not as a cross section). According to Parsons aquifer designations, the HGRK-PRTMWI wells monitor the shallow zone, 15 to 20 feet deep (-05 to –10 feet MSL).

The HKS wells, along with the MWI wells monitor the intermediate zone (25 to 35 feet bls). The HGRK-PRTMWD wells monitor the top of the deep zone (35 to 40 feet bls and 25 to 30 feet msl) and the HKD wells generally monitor the base of the deep zone, along with several MWD wells.

For the purposes of this report, the aquifer designations will be changed slightly. The HGRK-PRTMWI wells will be called intermediate and the HGRK-PRTMWD wells will be called deep. These designations are used because these wells serve to monitor the PeRT Wall at depths intermediate and deep relative to the wall itself.

4.4.3 Precipitation

Rainfall data for 1997 and 1998 were obtained in order to evaluate aquifer responses to precipitation. The data were obtained from two stations in the vicinity of Cape Canaveral; the NOAA weather station at Titusville, FL, and from the Base weather station. The Titusville, FL station data includes the long-term data upon which the monthly 30-year normal rainfall values are based. The monthly 30-year normal rainfall values are used to calculate the cumulative departure from normal rainfall.

Both station's monthly rainfall totals follow a similar trend over the past two-year period (see top plot in Figure 4-15). However, the Base rainfall total for the two years is only 80 percent of that for the Titusville, FL station. To allow the evaluation of rainfall trends for the Base rainfall amounts, the Titusville, FL monthly 30-year normal rainfall values were multiplied by 80 percent to normalize them with the Base station precipitation values. As shown on the lower plot of Figure 4-15, a significant above-normal period of rainfall occurred between October 1997 and February 1998. Following this was a drought until December 1998, interrupted by above normal rainfall in September 1998.

4.4.4 Potentiometric Head Relationships

During the course of this study, twelve sets of water-level measurements were collected from most of the wells in the Hangar K area. Ten sets of measurements were collected from the HGRK-PRTMW wells. Potentiometric maps of three zones have been prepared, including the intermediate zone at the top and base of the deep zone. The base of the deep zone is actually below the PeRT wall and provides information on flow in the zone beneath the wall. The intermediate zone plot is limited to the immediate vicinity of the PeRT wall covering an area of approximately 10 feet by 100 feet. The top of the deep aquifer zone covers a much larger area, approximately 725 feet by 300 feet. The base of the deep aquifer map covers approximately the same area as the deep wells.

Groundwater flow directions in the immediate vicinity of the PeRT Wall are quite variable. In the intermediate zone, the flow ranges from northwest to southeast, or reverse to the anticipated flow direction. Figure 4-16 shows the potentiometric surface of the intermediate depth-zone wells for February 19, 1998. Based upon the potentiometric maps, the flow directions are as follows:

- away from the wall (reversed upgradient) along the southwest end
- parallel to the wall from the southwest end to the center of the wall
- through the wall along the center of the JAG wall

The reversed flow apparent at the southwest end of the wall between wells HGRK-PRTMWI01 and –I02, may be the result of groundwater flow around the edge of the wall. This type of flow could occur if the wall was plugged near its end. Groundwater may not mound but instead, may flow around the end of the wall. If the wall is plugged between these two wells, then the flow is not reversed but is flowing parallel to the wall on both its up and down gradient sides. Table 4-28 lists the flow directions for eleven segments of the wall, for each of the ten sets of water level measurements. Table 4-29 lists the water-level elevations and the horizontal head differences for each of the six pairs of wells located across the PeRT wall from each other. The range of horizontal head differences between these six well sets range from –0.04 to +0.07 feet, with an average of 0.02 feet. The head difference between these two wells (I01/I02) range from –0.04 to –0.01 feet, with most being –0.02 feet. Given the limitations in accuracy of surveying, +/- 0.01 foot, and water level measurement, +/- 0.05 foot, it is possible that the water levels were actually flat and a .01 or .02 foot error in measurement occurred.

Flow directions at the top of the deep depth-zone are fairly consistent though some variability exists (Table 4-28). Flow directions are predominantly northwest to northeast, with reversed flow apparently

occurring at one location near the southwest extent of the JAG wall. Figure 4-17 shows the potentiometric surface of the top of the deep zone on February 19, 1998. Flow appears to be reversed at wells HGRK-PRTMWD13 and D14. This phenomenon occurs on 70% of the measurements. As shown in Table 4-29, the horizontal head differences between these six deep-well sets range from –0.05 to +0.18 feet, with an average of 0.025 feet. The head difference between well set HGRK-PRTMWD13 and D14 wells range from –0.05 to +0.05 feet. Two of the other three times the head measurements were taken, the difference was 0.00 feet. It could be that the water levels at this location were actually flat and a .01 or .02 foot error in measurement occurred.

Flow directions for most of the deep zone wells, listed in Table 4-30, are less variable than for the deep-zone wells immediately around the PeRT Wall. Figures 4-18 and 4-19 show the deep aquifer-zone potentiometric maps for the Hangar K/PeRT Wall area, for February 19, 1998 and November 16, 1998, respectively. These water-surface shapes are fairly typical for this aquifer zone during the 14-month period. The highest water elevation is at well HK7S, with the next highest being at well MWI16. For both maps, some radial flow components are evident, generally trending towards the west, northwest, and northeast. On the November 16, 1998 potentiometric surface shown in the figure, flow is from the middle of the PeRT Wall area to the southeast, towards well HK10S, which is an exception to the earlier data shown in Figure 18. At this well the water elevation is 0.03 feet lower than well HGRK-PRTMWD13, located at the wall. This apparent flow reversal, given the small head differences, may be indicative of a flat water-surface in this area. It may also indicate that the water is starting to back up behind the wall, and ultimately force water around or below it. This may be evidence that wall is plugging; however, more water-level data collection and evaluation will be necessary to reveal if this trend exists and continues. Additional monitoring by others is being done.

The flow direction at the base of the deep zone (below the PeRT walls) ranges from west to northwest for nearly all the contoured area, see Table 4-30. Figure 4-20 shows the potentiometric map for the Hangar K/PeRT Wall area, for November 16, 1998. This water-surface shape is fairly typical of the 14-month period. The flow direction in this deeper zone is not radial but predominantly from east to west. This flow direction is consistent throughout the period of water-level measurements. These potentiometric surface maps do not show any apparent influence from the PeRT Wall.

Tidal influence on groundwater elevations and flow direction was not evaluated as part of this investigation. An investigation of Banana River influence on wells west of Hangar K was performed in 1996 (Parsons ES, 1996b). This seven week study showed a maximum river influence on shallow and intermediate depth wells to be 1.3 feet. These fluctuations were over several days not 12-hours as the

tidal cycle at Cape Canaveral. Within the continuous water level data plot are short-duration (approximately 12-hours), fairly regular fluctuations that may be tidal influence. These fluctuations are of the order of magnitude of 0.10 to 0.15 feet. Since most sets of water levels were collected within a three-hour period (or one-half a tidal rise or fall period) during the PeRT wall pilot study, the impact would be even less than the full cycle. The tidal effects have not been evaluated as far inland as Hangar K. Therefore, no conclusions have been made regarding possible tidal influence on pilot study results.

Hydrographs were prepared to evaluate water level fluctuations over time. Figure 4-21 and 4-22 are selected hydrographs. Figure 4-21 shows water level trends impacted by recharge conditions that changed from relatively normal to drought and returned to normal. However, no changes that were caused by the PeRT Wall are apparent.

Figure 4-22 shows hydrographs from selected well pairs. Note that the water level at well HK20S tracks nearly on top of those for HGRK-PRTMWI20 and D20 for most of the plot. These well pairs are 95 feet apart. This data indicates that no change in the head relationships due to the wall has occurred. However, on November 16, 1998, the water levels at HGRK-PRT MWI20 and D20 are higher than the water level at wall HK20S. The head differences across the wall are slight because of small distances between wells. These higher water levels may indicate that some mounding may be beginning to occur near the northeast end of the wall. Further data is being collected by others to verify this trend.

Groundwater flow gradients at the Hangar K area are low. Table 4-31 lists the horizontal flow gradients for the well sets at the PeRT Wall. The gradients in the intermediate zone range from –0.00965 to 0.0585 feet per foot, with an average of 0.0082 feet per foot. The negative value indicates a reversed flow direction. These negative gradients may not be valid if the PeRT Wall is plugged in that area since the wells would not be interconnected hydraulically. In the deep zone, gradients range from –0.0021 to 0.053 feet per foot, with an average of 0.0074 feet per foot. Horizontal flow velocities, assuming a hydraulic conductivity of 1.0 feet per day, range from –0.039 to 0.068 feet/day in the intermediate zone and from –0.053 to 0.083 feet/day in the deep zone. Average velocity is 0.03 feet/day in the intermediate zone and 0.03 feet/day in the deep zone. This average velocity indicates that the groundwater travels one foot in approximately 33 days in both zones.

A similar evaluation of groundwater horizontal flow gradients and velocities was performed for the deep and bottom aquifer zones over the broader, Hangar K area. The groundwater horizontal flow gradients and velocity for deep wells, see Table 4-32, are much lower than through the PeRT Wall. In the downgradient (west) area, horizontal flow gradients range from 0.00109 to 0.00171 feet/foot, averaging

0.0014 feet/foot. Horizontal flow velocities range from 0.0055 to 0.0085 feet/day, averaging 0.0072 feet/day. In the PeRT Wall area, horizontal flow gradients range from 0.00045 to 0.0013 feet/foot, averaging 0.00092 feet/foot. Horizontal flow velocities range from 0.0023 to 0.0064 feet/day, averaging 0.0046 feet/day. In the upgradient (east) area, horizontal flow gradients and horizontal flow velocities were not estimated because of the radial flow pattern. The flow in the eastern area is away from the PeRT Wall area and, therefore, considered to not be of importance to this study. The downgradient area has a greater flow velocity than the area below the PeRT Wall. This pattern has been consistent throughout the 14-month period, beginning before the PeRT Wall was installed. This average velocity means the groundwater travels one foot in over 139 days in the downgradient area and travels one foot in over 218 days in the PeRT Wall area.

The estimated horizontal gradient and flow velocities in the immediate area of the PeRT Wall are approximately six to seven times greater than the those in the regional deep and base aquifer zones. This could be the result of the influence of the geologic material the wells are screened in. Given the low groundwater gradient in the area, and the closeness of the wells, geologic variation could have a significant impact on water levels.

4.5 FLOW SENSOR RESULTS

The flow sensors were installed, as described in Section 4.0, at six locations at a depth of 40 feet. This places these flow sensors in the deep aquifer zone. The sensor locations are upgradient and downgradient of each of the two PeRT Wall segments, and one beyond either end of the entire PeRT Wall. Summarized results for six flow sensors are presented in tables 4-22 to 4-27. Two of the sensors, PRT 03 and PRT 16, had ERMS values greater than 0.30, indicating that the uncertainty in fitting the data to the theoretical curve is unacceptably high.

Shown at the bottom of the six tables 4-22 through 4-27 are three plots. On the left is a plot of the direction and magnitude of the horizontal flow component for each of the dates listed in the table. The PeRT wall segments are oriented at North 41° East. The dark line labeled as the PeRT wall in the left-hand figure relates the flow direction arrows to the actual wall position. In the middle is a schematic map showing the position of the flow sensor, relative to the PeRT wall segments. On the right is a plot of the direction and magnitude of the vertical flow component.

The plots show that on the upgradient side of the Mandrel PeRT wall (PRT03), the flow is up and at an angle to the wall. On the downgradient side of the wall (PRT05) flow is down and rotated 135° counter

clockwise from the upgradient side. On the south west end of the wall (PRT10), flow is down and roughly perpendicular to the wall. On the upgradient side of the JAG PeRT wall (PRT15) flow is down and again at an angle to the wall. On the downgradient side of the wall (PRT16) flow is upward and reverse, i.e., back towards the wall. On the northeast end of the wall (PRT21) flow is down and at an angle to the wall.

These data indicate the flow around the PeRT wall segments is quite variable, while being fairly consistent in direction and magnitude at each sensor location. The reverse flow direction at PRT16 may indicate flow around the short JAG wall segment downgradient of the main PeRT wall. It should be noted that the results for sensors PRT03 and PRT16 are highly questionable, as the ERMS values exceeded 0.30 (see Section 4.3.4 for discussion of ERMS significance).

Table 4-33 summarizes the average values for all six sensors. There is no hydraulic conductivity data (horizontal or vertical) available for this area. Therefore, no calibration is possible for the various flow values recorded. In many cases the vertical flow velocity appears to be greater than the horizontal velocity. The horizontal flow velocities are in the same range as those estimated from the groundwater elevation data (estimated average horizontal flow velocity of 0.030 compared to flow sensor horizontal flow velocity of 0.059 feet/day). For a given sensor, the horizontal velocity may be tangential to the wall.

4.6 USEFUL LIFETIME OF PeRT WALLS

There are three issues that can potentially limit the longevity of a PeRT wall: (1) dissolution, (2) clogging, and (3) passivation. Dissolution of Fe^{+0} occurs during the corrosion process and leads to a decrease in the amount of Fe^{+0} available to degrade chlorinated VOCs. Clogging refers to the disruption of groundwater flow by mineral precipitation, microbial growth, or gas formation. If permeability in the PeRT wall decreases significantly, groundwater may be diverted and bypass the reactive zone without being treated. Passivation refers to the decreasing reactivity of the Fe^{+0}. Decreasing reactivity is attributed to the formation of minerals on the surfaces of the Fe^{+0} particles.

Estimates of mineral precipitation and dissolution are made based on observed groundwater chemistry and assumed reaction mechanisms. No theoretical base is available to reliably estimate the effects of surface passivation, so no calculations are presented. For this same reason, the effects of gas formation on clogging have not been estimated. As discussed above, the observed groundwater chemistry may be

misinterpreted due to the slow rate of groundwater flow. Therefore, the calculations presented in this section should be considered as rough approximations.

Biological activity may also contribute to the decrease in effectiveness of PeRT walls. Hydrogen gas produced by Fe^{+0} corrosion is capable of donating electrons to microbial acceptors. Biomass and biogenic gasses could cause clogging of pores. There is currently only a limited understanding of the effects of these microbial processes in PeRT walls. A few microbial investigations have been performed at other sites and have suggested that microbes are not likely to play a significant role in PeRT wall performance (Gavaskar et al., 1998). Therefore, the discussion below is limited to abiotic processes.

There is limited operational history with which to reliably assess the length of time that PeRT walls will remain functional. The first demonstration of a Fe^{+0} PeRT wall was at the Canadian Forces Base Borden site. After almost 5 years of operation, the Fe^{+0} at this site still had a fresh appearance and there was minimal amount of mineral precipitation clogging pores (O'Hannesin and Gillham, 1998). The first commercial installation of Fe^{+0} in a PeRT wall was at the Intersil site at Sunnyvale, California. This wall has been successfully treating VOCs for over 4 years. Groundwater mounding behind PeRT walls has been reported at some sites, such as at the Denver Federal Center, which may be the result of clogging within the wall. Alternatively, the mounding may be due to a low permeability zone caused by the smearing of clays as the sheet pilings were driven during installation.

The concentration of total dissolved iron is less than 1 mg/L in most groundwater samples at the CCAS PeRT wall site and does not show a consistent trend from upgradient to downgradient of the wall. If the iron dissolved from the PeRT wall remained in solution, the dissolution rate could be easily calculated from the dissolved concentrations. However, as discussed in Section 5.2, the Fe^{2+} can precipitate in carbonate, sulfide, and hydroxide minerals. Therefore, theoretical calculations must be used to estimate Fe^{+0} dissolution. Four corrosion agents were evaluated to estimate their affect on Fe^{+0} dissolution: (1) dissolved oxygen, (2) water, (3) c/t DCE, and (4) vinyl chloride.

The dissolved oxygen concentration is about 0.3 mg/L and does not show a consistent trend from upgradient to downgradient of the PeRT wall. Since the redox state indicates reduction occurs across the wall, it is likely that the dissolved oxygen measurements were influenced by oxygen from the atmosphere

during sampling. If we assume that the entire 0.3 mg/L of oxygen is being reduced by Fe^{+0}, 0.53 mg of iron per liter of groundwater would be dissolved.

Since water is in unlimited supply, the oxidation of Fe^{+0} with water could be substantial. However, because a mole of hydroxyl is generated for every mole of water reduced, the amount of iron released by the reduction of water can be estimated from the maximum pH. The maximum pH on the downgradient side of the PeRT wall is about 9.5. About 0.9 mg/L of iron is liberated with an increase in pH to 9.5. This estimate assumes that no acid-generation is occurring due to silicate reactions such as described by Powell and Puls (1997). If acid-generation occurs, additional Fe^{+0} will dissolve.

The concentration of c/t-DCE in the groundwater is about 115 mg/L. About 66 mg/L of dissolved iron is generated from the reductive dechlorination of this c/t-DCE. Similarly, about 51 mg/L of iron is generated from reductive dechlorination of vinyl chloride.

A total of 118 mg/L of iron is dissolved from all 4 processes, mostly from reductive dechlorination (Table 4-34). If 118 mg/L of iron is lost, it requires 1,067 years to dissolve a 4-inch thick wall of Fe^{+0} at a groundwater flow rate of 0.025 ft/day.

Changes in inorganic chemistry that occur from upgradient to downgradient of the PeRT wall can be used to partially evaluate the potential for the wall to clog. Average groundwater chemistry from November 1998 indicates that the redox state and alkalinity decrease, and that pH increases across the wall (Table 4-35). These chemical changes are characteristic of reactions with Fe^{+0} as discussed above, indicating that the groundwater was influenced by the PeRT wall. Maximum concentrations of carbonate, sulfide, and hydroxide minerals that can precipitate in the CCAS PeRT wall are estimated in this subsection.

In general, the groundwater alkalinity decreases from upgradient to downgradient wells, although on the average in deep wells the decrease is less than the standard deviation of the measured monthly readings (Table 4-18). As observed in the most recent data set (November 1998), the average alkalinity in the deep zone decreased across the PeRT wall by about 53 mg/L (as $CaCO_3$) (Table 4-34). The decrease in alkalinity is caused by the precipitation of carbonate minerals. Much of the carbonate has probably precipitated as calcite ($CaCO_3$) but other carbonate minerals such as siderite ($FeCO_3$) or magnesium

carbonate ($MgCO_3$) may have formed as well. A reasonable assessment of the potential for clogging can be calculated by assuming all of the decrease in alkalinity is due to calcite precipitation. Using this assumption, calcite will clog approximately 0.2% of the available pore space per year. The entire available pore space would be filled with calcite in 459 years. Alkalinity decreases across the PeRT wall in the intermediate zone by approximately the same amount indicating that a similar amount of calcite would be deposited there.

The sulfate concentration in the groundwater was consistently below the detection limit of 50 mg/L on both the upgradient and downgradient sides of the PeRT wall. Assuming that all 50 mg/L was precipitated as FeS in the wall (an unlikely scenario), the available pore space would decrease by 0.06% per year. At this rate, it would take 1,785 years to clog all available pore space with FeS.

If all of the dissolved iron (118 mg/L) were deposited as ferrous hydroxide [$Fe(OH)_2$], the available pore space would decrease by 0.17% per year. This calculation corrects for the pore volume that is gained due to dissolution of the Fe^{+0}. At this rate it would take 581 years to fill all the available pore space with $Fe(OH)_2$.

Existing PeRT walls at other sites have operated effectively for over 5 years. About 118 mg/L of iron is expected to be released from the CCAS PeRT wall, most of which is likely to precipitate within or just downgradient of the PeRT wall. At this rate of dissolution, the Fe^{+0} in a 4-inch wall will completely dissolve in about 1,000 years. The wall would become ineffective for degrading chlorinated VOCs to their MCLs prior to that time.

Conservative estimates of mineral precipitation suggest that over a 100 year period the following are maximum percentages of the available pore space that could be filled: carbonates, 20%; sulfides, 6%; and hydroxides, 17%. If these rates of mineral formation persist, porosity in the wall would decrease to zero in about 400 years and groundwater flow may be significantly diverted earlier. These estimates are preliminary and should be reevaluated after another year of groundwater monitoring.

4.7 MONITOR WELL HEADSPACE SCREENING

Samples of vapors in the headspaces of monitoring wells HGRK-PRTMWI16 and HGRK-PRTMWI17 were tested with detector tubes during the June, July and August 1998 sampling events. The samples were collected for Health and Safety purposes to protect sample collection personnel from potential harmful atmosphere. The samples were collected as follows:

1. The well cap was removed and replaced with a cap that has tubing from a pre-drilled hole in the center of the cap.
2. The explosimeter was used to evacuate the tubing and to obtain a % of LEL reading.
3. Draeger and Sensidyne tubes were opened and attached to the tubing, using a hand pump to draw samples.
4. For the June and July events, Draeger tubes were used in the following order: hydrogen, vinyl chloride and ethylene.
5. For the August event, Sensidyne and Draeger tubes were used as follows:
   First event: acetylene (Sensidyne), hydrogen (Draeger) and vinyl chloride (Draeger); Second event: ethylene (Draeger).

The results of the June sampling were as follows:

PARAMETER	HYDROGEN	VINYL CHLORIDE	ETHYLENE	% LEL
Standard Range	0.2 to 2 %	0.5 to 3 ppm	0.2 to 5 ppm	
HGRK-PRTMWI16	Not detected	0.5 ppm	Not detected	22
HGRK-PRTMWI17	Not detected	Not detected	>3.5 and < 15 ppm*	244

* The range is based on 3.5 ppm at half of the required strokes (10 out of 20) for the 0.2 ppm range. The results indicated the concentration was less than the upper end (15 ppm) of the scale for the 5-stroke range.

The Results of the July Sampling were as follows:

PARAMETER	HYDROGEN	VINYL CHLORIDE	ETHYLENE	% LEL
Standard Range	0.2 to 2 %	0.5 to 3 ppm	0.2 to 5 ppm	
HGRK-PRTMWI16	Not detected	2 ppm	0.2 ppm	122
HGRK-PRTMWI17	Not detected	Not detected	4.5 ppm	241

The Results of the first August Sampling were as follows:

PARAMETER	ACETYLENE	HYDROGEN	VINYL CHLORIDE	% LEL
Standard Range	32.5 to 1,000 ppm	0.2 to 2 %	0.5 to 3 ppm	
HGRK-PRTMWI16	50 ppm	Not detected	0.5 ppm	105
HGRK-PRTMWI17	80 ppm	Not detected	Not detected	80

The Results of the second August Sampling were as follows:

PARAMETER	ETHYLENE	% LEL
Standard Range	0.2 to 5 ppm	
HGRK-PRTMWI16	Not detected	43
HGRK-PRTMWI17	0.5	105

This testing was intended as a field screening primarily for health and safety purposes. Many of these type detector tubes are "cross sensitive" with other compounds. According to Draeger and Sensidyne, the following compounds will also give positive readings in the indicated tubes:

- Acetylene Tubes: Butane, carbon monoxide, butylene, propylene, pentane and hydrogen will show as acetylene in this tube.
- Hydrogen Tubes: No know interference from other compounds in this tube.
- Vinyl Chloride Tubes: Other halogenated hydrocarbons will show as vinyl chloride in this tube.
- Ethylene Tubes: Other compounds with Carbon-Carbon double bonds will show as ethylene in this tube.

TABLE 4-1
PILOT STUDY MONITOR WELL CONSTRUCTION DETAILS

Well Number	Date Installed	Total Well Depth		Screen and Casing Diameter (inches)	Screen Length (feet)	Riser Length (feet)	Screened Interval (feet bls)	Screened Interval (msl)	Top of Filter Sand (feet bls)	Top of Sand Seal (feet bls)	Top of Bentonite Seal (feet bls)	Date Developed
		(feet bls)	(msl)									
HGRK-PRTMWD01	1/18/98	39.02	-30.26	1.25	5	34.02	34.02 to 39.02	-25.26 to -30.26	32.6	31.5	29.5	1/24/98
HGRK-PRTMWD02	1/22/98	39.68	-30.93	1.25	5	34.68	34.68 to 39.68	-25.93 to -30.93	32.8	31	29	1/24/98
HGRK-PRTMWD03	1/21/98	39.45	-30.65	1.25	5	34.45	34.45 to 39.45	-25.65 to -30.65	33	32	30	1/24/98
HGRK-PRTMWD05	1/20/98	39.51	-30.74	1.25	5	34.51	34.51 to 39.51	-25.74 to -30.74	32.5	31.5	29.5	1/24/98
HGRK-PRTMWD07	1/17/98	39.54	-30.78	1.25	5	34.54	34.54 to 39.54	-25.78 to -30.78	33	32	30	1/18/98
HGRK-PRTMWD09	1/16/98	39.38	-30.61	1.25	5	34.38	34.38 to 39.38	-25.61 to -30.61	32	31	29	1/18/98
HGRK-PRTMWD11	1/15/98	38.81	-29.96	1.25	5	33.81	33.81 to 38.81	-24.96 to -29.96	33	31.75	29.75	1/16/98
HGRK-PRTMWD12	1/14/98	39.82	-31.08	1.25	5	34.82	34.82 to 39.82	-26.08 to -31.08	32	31	29	1/16/98
HGRK-PRTMWD13	1/13/98	39.16	-30.28	1.25	5	34.16	34.16 to 39.16	-25.28 to -30.28	32.5	31.5	29.5	1/14/98
HGRK-PRTMWD14	1/12/98	39.30	-30.47	1.25	5	34.30	34.30 to 39.30	-25.47 to -30.47	33	32	30	1/14/98
HGRK-PRTMWD15	1/11/98	39.37	-30.52	1.25	5	34.37	34.37 to 39.37	-25.52 to -30.52	32.5	31.5	29.5	1/13/98
HGRK-PRTMWD16	1/10/98	38.74	-29.88	1.25	5	33.74	33.74 to 38.74	-24.88 to -29.88	32.5	31	29	1/13/98
HGRK-PRTMWD17	1/9/98	39.00	-30.14	1.25	5	34.00	34.00 to 39.00	-25.14 to -30.14	33	32	30	1/16/98
HGRK-PRTMWD18	1/7/98	39.14	-30.30	1.25	5	34.14	34.14 to 39.14	-25.30 to -30.30	32	31	29	1/16/98
HGRK-PRTMWD19	1/3/98	39.34	-30.42	1.25	5	34.34	34.34 to 39.34	-25.42 to -30.42	33	32	30	1/6/98
HGRK-PRTMWD20	1/2/98	39.41	-30.60	1.25	5	34.41	34.41 to 39.41	-25.60 to -30.60	31	30	28	1/6/98
HGRK-PRTMWI01	1/18/98	19.00	-10.24	1.25	5	14.00	14.00 to 19.00	-5.24 to -10.24	13	12	10	1/24/98
HGRK-PRTMWI02	1/22/98	19.42	-10.67	1.25	5	14.42	14.42 to 19.42	-5.67 to -10.67	12.5	11.5	9.5	1/24/98
HGRK-PRTMWI03	1/21/98	19.05	-10.25	1.25	5	14.05	14.05 to 19.05	-5.25 to -10.25	12.8	11.5	9.5	1/24/98
HGRK-PRTMWI05	1/20/98	19.20	-10.43	1.25	5	14.20	14.20 to 19.20	-5.43 to -10.43	13	12	10	1/24/98
HGRK-PRTMWI07	1/17/98	19.04	-10.25	1.25	5	14.04	14.04 to 19.04	-5.25 to -10.25	13	12	10	1/18/98
HGRK-PRTMWI09	1/16/98	20.30	-11.54	1.25	5	15.30	15.30 to 20.30	-6.54 to -11.54	12.8	11.5	9.5	1/18/98
HGRK-PRTMWI11	1/15/98	18.92	-10.08	1.25	5	13.92	13.92 to 18.92	-5.08 to -10.08	12.75	11.75	9.75	1/16/98
HGRK-PRTMWI12	1/14/98	20.01	-11.17	1.25	5	15.01	15.01 to 20.01	-6.17 to -11.17	12.3	11	9	1/16/98
HGRK-PRTMWI13	1/13/98	19.40	-10.54	1.25	5	14.40	14.40 to 19.40	-5.54 to -10.54	13	12	10	1/14/98
HGRK-PRTMWI14	1/12/98	19.32	-10.50	1.25	5	14.32	14.32 to 19.32	-5.50 to -10.50	13	12	10	1/14/98
HGRK-PRTMWI15	1/11/98	19.30	-10.42	1.25	5	14.30	14.30 to 19.30	-5.42 to -10.42	13	12	10	1/13/98
HGRK-PRTMWI16	1/10/98	19.88	-11.04	1.25	5	14.88	14.88 to 19.88	-6.04 to -11.04	13	12	10	1/13/98
HGRK-PRTMWI17	1/9/98	19.04	-10.44	1.25	5	14.04	14.04 to 19.04	-5.44 to -10.44	12.5	11	9	1/16/98
HGRK-PRTMWI18	1/7/98	19.02	-10.22	1.25	5	14.02	14.02 to 19.02	-5.22 to -10.22	12.8	11.75	9.75	1/16/98
HGRK-PRTMWI19	1/3/98	19.00	-10.08	1.25	5	14.00	14.00 to 19.00	-5.08 to -10.08	12.5	11.5	9.5	1/6/98
HGRK-PRTMWI20	1/2/98	19.21	-10.30	1.25	5	14.21	14.21 to 19.21	-5.30 to -10.30	12.75	11.75	9.75	1/6/98

TABLE 4-2
VINYL CHLORIDE CONCENTRATION SUMMARY

Well No.	VINYL CHLORIDE CONCENTRATION (ug/L)					
	Feb-98	May-98	Aug-98	Nov-98	Average	Standard Deviation
HGRK-PRTMWD01	58,000 D/	33,000	70,000	70,900 /KT	57,975	17,658
HGRK-PRTMWD01a		43,000				
HGRK-PRTMWD02	20,000 D/	47,000	91,000	71,400 /KT	57,350	30,724
HGRK-PRTMWD03	5,700 D/JI	42,000	55,600	67,400 /KT	42,675	26,746
HGRK-PRTMWD03a	7,000 D/		60,000	70,900 /KT	45,967	34,183
HGRK-PRTMWD05	54,000 D/	55,000	82,000	69,300 /KT	65,075	13,272
HGRK-PRTMWD07	45,000 D/	35,000	68,000	43,800 /KT	47,950	14,091
HGRK-PRTMWD09	62,000 D/	42,000	71,000	58,900 /KT	58,475	12,123
HGRK-PRTMWD11	9,800 D/JI	31,000	30,500	63,000 /KT	33,575	21,963
HGRK-PRTMWD11a		28,000				
HGRK-PRTMWD12	4,800	33,000	68,000	95,200 /LT	50,250	39,576
HGRK-PRTMWD13	29,000 D/JI	26,000	25,100	35,100 /KT	28,800	4,519
HGRK-PRTMWD13a	27,000 D/JI		23,600	33,100 /KT		
HGRK-PRTMWD14	38,000 D/	40,000	64,000	47,000 /KT	47,250	11,815
HGRK-PRTMWD15	34,000	33,000	34,700	71,400 /KT	43,275	18,763
HGRK-PRTMWD15a		34,000				
HGRK-PRTMWD16	63,000 D/	67,000	98,600	86,100 /KT	78,675	16,675
HGRK-PRTMWD17	1,600 D/JI	53,000	120,000	86,000 /KT	65,150	50,430
HGRK-PRTMWD18	37,000	49,000	110,000	89,300 /KT	71,325	34,134
HGRK-PRTMWD19	15,000 D/JIA	22,000	33,400	34,700 /KT	26,275	9,437
HGRK-PRTMWD19a	35,000 /JI		24,600	36,400 /KT	32,000	6,447
HGRK-PRTMWD20	43,000 D/	39,000	100,000	83,400 /KT	66,350	30,090
HGRK-PRTMWI01	< 1.1	NS	< 1.1	NS	1.1	0.0
HGRK-PRTMWI02	52.0	NS	0.57 F/	NS	26.3	36.4
HGRK-PRTMWI03	< 1.1	NS	< 1.1	NS	1.1	0.0
HGRK-PRTMWI05	25.0	NS	< 1.1	NS	13.1	16.9
HGRK-PRTMWI07	66.0	NS	< 1.1	NS	33.6	45.9
HGRK-PRTMWI09	60.0	NS	< 1.1	NS	30.6	41.6
HGRK-PRTMWI11	0.9 F/JI	NS	< 1.1	NS	1.0	0.1
HGRK-PRTMWI12	8.4	NS	< 1.1	NS	4.8	5.2
HGRK-PRTMWI13	2.5	NS	1.5	NS	2.0	0.7
HGRK-PRTMWI14	210 D/	NS	5.3	NS	107.7	144.7
HGRK-PRTMWI15	29.0 /JI	NS	1.6	NS	15.3	19.4
HGRK-PRTMWI16	210 D/	NS	47.9	NS	129.0	114.6
HGRK-PRTMWI17	370	NS	5.5	NS	187.8	257.7
HGRK-PRTMWI18	490 D/	NS	3.4	NS	246.7	344.1
HGRK-PRTMWI19	220 D/	NS	4.9	NS	112.5	152.1
HGRK-PRTMWI20	100	NS	1.1 F/	NS	50.6	69.9

Notes:
1. See Table 4-6 for Data Qualifier Explanation.
2. If no value is listed, analyses were not performed for sample during specific event.
3. Sample numbers followed by an "a" are field duplicate samples.

NS = Not Sampled

TABLE 4-3
trans-1,2-DICHLOROETHENE CONCENTRATION SUMMARY

Well No.	trans-1,2-DICHLOROETHENE CONCENTRATION (ug/L)					
	Feb-98	May-98	Aug-98	Nov-98	Average	Standard Deviation
HGRK-PRTMWD01	490	800 F/	1,470	1,160	980	426
HGRK-PRTMWD01a		1,100				
HGRK-PRTMWD02	570 D/	860 F/	790	1,160	845	244
HGRK-PRTMWD03	1,600 /JI	1,600	1,750	1,580	1,633	79
HGRK-PRTMWD03a	1,600		1,800	1,620	1,673	110
HGRK-PRTMWD05	930	790	750	1,080	888	150
HGRK-PRTMWD07	190	< 500	220	261	293	141
HGRK-PRTMWD09	770	760 F/	770	715	754	26
HGRK-PRTMWD11	1,700 /JI	1,900	1,790	1,870	1,815	90
HGRK-PRTMWD11a		2,000				
HGRK-PRTMWD12	190	< 500	200	644 F/	384	225
HGRK-PRTMWD13	1,700 /JI	2,200	1,970	2,020	1,973	207
HGRK-PRTMWD13a	1,800 /JI		1,870	1,910		
HGRK-PRTMWD14	670	990 F/	800	710	793	142
HGRK-PRTMWD15	1,900	2,300	1,440	1,700	1,835	363
HGRK-PRTMWD15a		2,300				
HGRK-PRTMWD16	640	1,300	630	469	760	369
HGRK-PRTMWD17	740 D/JI	2,000	1,300	645	1,171	624
HGRK-PRTMWD18	1,500	1,400	990	871	1,190	307
HGRK-PRTMWD19	2,200 /JI	2,500	2,260	2,380	2,335	133
HGRK-PRTMWD19a	1,900 /JI		2,440	2,380	2,240	296
HGRK-PRTMWD20	950	1,900	790	1,860	1,375	587
HGRK-PRTMWI01	0.44 F/	NS	0.40 F/	NS	0.42	0.03
HGRK-PRTMWI02	< 0.50	NS	< 0.50	NS	0.50	0.00
HGRK-PRTMWI03	< 0.50	NS	0.45 F/	NS	0.48	0.04
HGRK-PRTMWI05	0.24	NS	< 0.50	NS	0.37	0.18
HGRK-PRTMWI07	0.13 F/	NS	< 0.50	NS	0.32	0.26
HGRK-PRTMWI09	< 0.50	NS	< 0.50	NS	0.50	0.00
HGRK-PRTMWI11	0.73 F/JI	NS	0.42 F/	NS	0.58	0.22
HGRK-PRTMWI12	< 0.50	NS	< 0.50	NS	0.50	0.00
HGRK-PRTMWI13	1.80	NS	1.40	NS	1.60	0.28
HGRK-PRTMWI14	2.00	NS	< 0.50	NS	1.25	1.06
HGRK-PRTMWI15	4.50 /JI	NS	1.80	NS	3.15	1.91
HGRK-PRTMWI16	1.80	NS	4.95	NS	3.38	2.23
HGRK-PRTMWI17	1.90	NS	< 0.50	NS	1.20	0.99
HGRK-PRTMWI18	13.00	NS	< 0.50	NS	6.75	8.84
HGRK-PRTMWI19	2.50	NS	1.30	NS	1.90	0.85
HGRK-PRTMWI20	2.00	NS	< 0.50	NS	1.25	1.06

Notes:
1. See Table 4-6 for Data Qualifier Explanation.
2. If no value is listed, analyses were not performed for sample during specific event.
3. Sample numbers followed by an "a" are field duplicate samples.

NS = Not Sampled

TABLE 4-4
cis-1,2-DICHLOROETHENE CONCENTRATION SUMMARY

Well No.	cis-1,2-DICHLOROETHENE CONCENTRATION (ug/L)					
	Feb-98	May-98	Aug-98	Nov-98	Average	Standard Deviation
HGRK-PRTMWD01	93,000 D/	57,000	89,900	69,800 /KFT	77,425	17,064
HGRK-PRTMWD01a		73,000				
HGRK-PRTMWD02	40,000 D/	45,000	41,000 M/	49,100 /KFT	43,775	4,156
HGRK-PRTMWD03	35,000 D/JI	100,000	121,000	103,000 /KFT	89,750	37,660
HGRK-PRTMWD03a	41,000 D/		120,000	105,000 /KFT	88,667	41,956
HGRK-PRTMWD05	93,000 D/	45,000	39,000 M/	47,400 /KFT	56,100	24,852
HGRK-PRTMWD07	52,000 D/	17,000	15,000 M/	9,890 /KFVT	23,473	19,253
HGRK-PRTMWD09	68,000 D/	47,000	50,000 M/	31,300 /KFT	49,075	15,047
HGRK-PRTMWD11	75,000 D/JI	140,000	147,000	134,000 /KFT	124,000	33,096
HGRK-PRTMWD11a		150,000 M/				
HGRK-PRTMWD12	87,000 D/	48,000	23,000	3,270 /LFT	40,318	36,105
HGRK-PRTMWD13	59,000 D/JI	150,000 M/	151,000	142,000 /KT	125,500	44,516
HGRK-PRTMWD13a	59,000 D/JI		145,000	144,000 /KT		
HGRK-PRTMWD14	47,000 D/	51,000	33,000 M/	19,100 /KFT	37,525	14,506
HGRK-PRTMWD15	160,000	160,000 M/	96,800	101,000 /KT	129,450	35,318
HGRK-PRTMWD15a		150,000 M/				
HGRK-PRTMWD16	28,000 D/	69,000	11,800 M/	4,450 /KFT	28,313	28,854
HGRK-PRTMWD17	5,000 D/JI	98,000	40,000 M/	3,270 /KFT	36,568	44,313
HGRK-PRTMWD18	97,000	76,000	17,000 M/	12,100 /KFT	50,525	42,463
HGRK-PRTMWD19	170,000 D/JI	150,000 M/	145,000	137,000 /KT	150,500	14,059
HGRK-PRTMWD19a	190,000 D/JI		146,000 /M	142,000 M/KT	159,333	26,633
HGRK-PRTMWD20	42,000 D/	110,000	14,000 M/	107,000 /KFT	68,250	47,877
HGRK-PRTMWI01	0.9 F/	NS	1.2 F/	NS	1.1	0.2
HGRK-PRTMWI02	93	NS	2.6	NS	47.8	63.9
HGRK-PRTMWI03	< 1.2	NS	1.4	NS	1.3	0.1
HGRK-PRTMWI05	38	NS	0.7 F/	NS	19.4	26.4
HGRK-PRTMWI07	210 D/	NS	3.0	NS	106.5	146.4
HGRK-PRTMWI09	48	NS	2.2	NS	25.1	32.4
HGRK-PRTMWI11	3.5 /JI	NS	9.5 M/m	NS	6.5	4.2
HGRK-PRTMWI12	38	NS	1.8	NS	19.9	25.6
HGRK-PRTMWI13	16	NS	6.1 M/	NS	11.1	7.0
HGRK-PRTMWI14	250 D/	NS	2.6	NS	126.3	174.9
HGRK-PRTMWI15	65 /JI	NS	7.6 M/	NS	36.3	40.6
HGRK-PRTMWI16	170 D/	NS	67.5	NS	118.8	72.5
HGRK-PRTMWI17	65	NS	1.6	NS	33.3	44.8
HGRK-PRTMWI18	470 D/	NS	1.6	NS	235.8	331.2
HGRK-PRTMWI19	160 D/	NS	6.2 M/	NS	83.1	108.8
HGRK-PRTMWI20	98	NS	0.6 F/	NS	49.3	68.8

Notes:
1. See Table 4-6 for Data Qualifier Explanation.
2. If no value is listed, analyses were not performed for sample during specific event.
3. Sample numbers followed by an "a" are field duplicate samples.

NS = Not Sampled

TABLE 4-5
1,1-DICHLOROETHENE CONCENTRATION SUMMARY

Well No.	1,1-DICHLOROETHENE CONCENTRATION (ug/L)					
	Feb-98	May-98	Aug-98	Nov-98	Average	Standard Deviation
HGRK-PRTMWD01	< 120	< 1,200	173	142	409	528
HGRK-PRTMWD01a		< 1,200				
HGRK-PRTMWD02	< 120	< 1,200	27 F/	110	364	559
HGRK-PRTMWD03	190 /JI	< 1,200	231	212	458	495
HGRK-PRTMWD03a	190		240	213	214	25
HGRK-PRTMWD05	< 120	< 1,200	50 F/	105	369	555
HGRK-PRTMWD07	< 120	< 1,200	< 120	< 120	390	540
HGRK-PRTMWD09	80 F/	< 1,200	33 F/	57 F/	342	572
HGRK-PRTMWD11	250 /JI	< 1,200	316	294	515	457
HGRK-PRTMWD11a		< 1,200				
HGRK-PRTMWD12	< 120	< 1,200	< 120	< 1,200	660	624
HGRK-PRTMWD13	270 /JI	270 F/	318	< 120	245	86
HGRK-PRTMWD13a	280 /JI		303	335		
HGRK-PRTMWD14	< 120	< 1,200	38 F/	25 F/	346	571
HGRK-PRTMWD15	240	300 F/	193	245	245	44
HGRK-PRTMWD15a		300 F/				
HGRK-PRTMWD16	< 120	< 1,200	< 120	< 120	390	540
HGRK-PRTMWD17	260 I/JI	< 1,200	39 F/	< 120	405	538
HGRK-PRTMWD18	140	< 1,200	< 120	< 120	395	537
HGRK-PRTMWD19	260 /JI	< 1,200	280	340	520	455
HGRK-PRTMWD19a	< 600		321	338	420	156
HGRK-PRTMWD20	< 120	< 1,200	< 120	222	416	525
HGRK-PRTMWI01	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI02	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI03	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI05	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI07	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI09	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI11	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI12	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI13	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI14	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI15	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI16	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI17	< 1.2	NS	< 1.2	NS	1.2	0.0
HGRK-PRTMWI18	0.75 F/	NS	< 1.2	NS	1.0	0.3
HGRK-PRTMWI19	0.26 F/	NS	< 1.2	NS	0.7	0.7
HGRK-PRTMWI20	< 1.2	NS	< 1.2	NS	1.2	0.0

Notes:
1. See Table 4-6 for Data Qualifier Explanation.
2. If no value is listed, analyses were not performed for sample during specific event.

NS = Not Sampled

TABLE 4-6
DATA QUALIFIER EXPLANATIONS

Modifier	Description
<	Indicates not detected at the reporting limit indicated. If "J" flags are utilized in the reporting, the "<" indicates not detected down to 10% of the reporting limit indicated.
/	Separates the analytical laboratory data qualifier from the Rust data qualifier (ex., Kemron/Rust).
Kemron Data Flag Descriptions	
D	The analyte was quantified at a secondary dilution factor.
F	Present below nominal reporting limit (AFCEE only).
I	Semi-quantitative result, out of instrument calibration range.
M	A matrix effect was present.
R	The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
X	m-Xylene and p-Xylene are unresolvable compounds.
Rust Data Flag Descriptions	
A	Field duplicate RPDs exceeded established criteria.
c	Laboratory control recovery below established criteria.
F	Detected in the associated field (i.e., ambient) blank.
I	Surrogate recovery above the upper limit.
J	Estimated value.
K	Common laboratory artifact detected at a concentration greater than 10X that detected in the associated field or laboratory blanks, or some other artifact detected at a concentration greater than 5X that detected in the associated field or laboratory blanks. Professional judgment must be used to determine if the detect is site-related.
L	Common laboratory artifact detected at less than 10X that detected in the associated field or laboratory blanks, or some other artifact detected at less than 5X that detected in the associated field or laboratory blanks. Not considered site-related per EPA data evaluation guidance.
m	Matrix spike sample percent recovery below established limits.
R	The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
T	Detected in the associated trip blank.
V	Detected in the associated equipment rinsate blank.

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Total Well Depth (ft. bls)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)	Depth to Water (ft. below TOC)
HGRK-PRTMWD01	2/23/98	0911	39.02	77.0	7.42	815	2.4	0.6	0.7	480	-109	<50	0.4	440	2%	3.94
HGRK-PRTMWD02	2/20/98	1016	39.68	78.1	8.27	747	1.8	0	0	400	-139	<50	0.4	360	4%	3.92
HGRK-PRTMWD03	2/23/98	0947	39.45	79.5	8.41	810	1.5	0	0	420	-67	<50	0.4	420	4%	2.99
HGRK-PRTMWD05	2/20/98	1057	39.51	80.4	7.73	810	1.6	0.5	0.4	460	-150	<50	0.4	440	2%	3.26
HGRK-PRTMWD07	2/19/98	1558	39.54	79.9	8.69	730	790	1.4	0.6	280	-240	<50	0.4	260	17%	4.55
HGRK-PRTMWD09	2/19/98	1430	39.38	79.9	7.29	810	5.3	0.5	0.5	480	-200	125	0.4	380	2%	3.91
HGRK-PRTMWD11	2/23/98	1039	38.81	77.4	7.80	810	2.1	0.4	0.4	460	-120	100	0.4	360	2%	3.05
HGRK-PRTMWD12	2/20/98	1217	39.82	80.6	8.14	810	1.7	0.2	0.2	440	-216	90	0.2	280	1%	3.29
HGRK-PRTMWD13	2/23/98	1124	39.16	80.1	7.87	815	0.92	0.4	0.4	480	-146	65	0.4	420	0%	3.17
HGRK-PRTMWD14	2/20/98	1256	39.30	81.3	8.60	800	1.7	0	0	440	-204	<50	0.2	320	3%	3.4
HGRK-PRTMWD15	2/23/98	1240	39.37	82.9	7.63	820	1.4	0.4	0.4	480	-174	<50	0.4	420	0%	3.07
HGRK-PRTMWD16	2/20/98	1334	38.74	84.0	8.84	820	1.0	0	0	460	-215	70	0.2	360	3%	3.41
HGRK-PRTMWD17	2/20/98	0932	39.00	79.2	7.73	812	1.4	0.2	0.2	460	-197	150	0.4	320	0%	4.00
HGRK-PRTMWD18	2/19/98	1511	39.14	82.9	9.23	790	3.7	0	0	380	-204	175	0.4	260	0%	4.26
HGRK-PRTMWD19	2/23/98	1313	39.34	80.2	9.36	800	3.5	0	0	340	-152	<50	0.4	360	0%	3.15
HGRK-PRTMWD20	2/23/98	1355	39.41	81.0	7.60	815	1.8	0.7	0.6	520	-148	<50	0.2	420	0%	3.06
HGRK-PRTMWI01	2/18/98	1344	19.00	80.2	7.72	310	1.1	0.4	0.4	188.1	14	<50	0.2	187	0%	3.81
HGRK-PRTMWI02	2/17/98	1544	19.42	87.4	9.34	130	62.3	0	0	34.2	-193	<50	0.4	45	0%	3.78
HGRK-PRTMWI03	2/18/98	1420	19.05	81.0	7.72	325	0.7	0.4	0.4	205.2	-42	<50	0.2	187	0%	3.82
HGRK-PRTMWI05	2/17/98	1610	19.20	87.1	9.41	135	3.8	0	0	32	-165	<50	0.8	60	0%	3.86
HGRK-PRTMWI07	2/17/98	1357	19.04	89.8	9.43	100	6.2	0	0	19	-158	<50	0.2	40	0%	3.85
HGRK-PRTMWI09	2/17/98	1320	20.30	89.6	9.81	120	6.9	0	0	23	-218	<50	0.4	40	1%	3.84
HGRK-PRTMWI11	2/18/98	1454	18.92	81.0	7.71	305	0.1	0.6	0.5	205.2	-42	<50	0.4	200	1%	3.91
HGRK-PRTMWI12	2/18/98	1015	20.01	80.6	7.50	130	1.1	0	0	27	-157	<50	0.4	15	0%	3.91
HGRK-PRTMWI13	2/18/98	1539	19.40	81.3	7.89	405	3.7	0.6	0.4	188.1	-109	<50	0.2	180	0%	4.05
HGRK-PRTMWI14	2/18/98	1105	19.32	82.2	9.58	280	0.6	0	0	136.8	-98	<50	0.4	80	7%	3.94
HGRK-PRTMWI15	2/18/98	1612	19.30	81.7	8.80	399	1.1	0.2	0.2	205.2	-104	<50	0.4	200	2%	3.94
HGRK-PRTMWI16	2/18/98	1232	19.88	83.8	8.08	575	1.4	0.4	0.4	290.7	-109	<50	0.2	300	44%	3.93
HGRK-PRTMWI17	2/17/98	1514	19.04	88.3	8.00	750	1.5	0	0	513	-137	<50	0.2	800	14%	3.85
HGRK-PRTMWI18	2/17/98	1437	19.02	88.5	9.10	370	4.75	0	0	119.7	-201	<50	0.2	135	1%	3.9
HGRK-PRTMWI19	2/18/98	1646	19.00	81.0	8.45	375	2.8	0	0.2	170	-150	<50	0.4	160	15%	4.02
HGRK-PRTMWI20	2/18/98	1305	19.21	81.0	8.95	570	0.8	0.6	0.2	290.7	-78	<50	0.2	238	0%	4.04

790	The turbidity reading for HGRK-PRTMWD07 in February is believed to be accurate. Althought subsequent clearing occurred, the development records show that during the first sampling event the purge water had color. Readings and descriptions for each purge volume are as follows: 1) 36.2 N.T.U, no color; 2) 3,500 N.T.U., medium grey; 3) 790 N.T.U. light grey.

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Total Well Depth (ft. bls)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)	Depth to Water (ft. below TOC)
HGRK-PRTMWD01	3/18/98	1328	39.02	78.2	7.70	1266	3	0.7	0.7	480	-114	<50	0.2	480	1%	4.36
HGRK-PRTMWD02	3/18/98	0952	39.68	81.0	8.32	1190	1	0	0	420	-170	<50	0.3	400	0%	4.24
HGRK-PRTMWD03	3/18/98	1350	39.45	80.0	8.23	1240	0	0	0	440	-102	<50	0.3	440	1%	4.35
HGRK-PRTMWD05	3/18/98	1026	39.51	83.9	7.83	1366	0	0.5	0.3	480	-156	<50	0.2	480	7%	4.65
HGRK-PRTMWD07	3/18/98	0909	39.54	79.5	8.48	1085	9	1.5	0.6	320	-209	<50	0.4	260	90%	5.09
HGRK-PRTMWD09	3/17/98	1625	39.38	79.1	7.70	1166	1	0.4	0.5	440	-139	70	0.2	340	4%	4.24
HGRK-PRTMWD11	3/18/98	1413	38.81	78.3	7.92	1270	2	0.5	0.2	480	-130	80	0.2	420	0%	4.37
HGRK-PRTMWD12	3/18/98	1056	39.82	80.0	8.34	1247	0	0	0	420	-225	<50	0.3	260	1%	4.21
HGRK-PRTMWD13	3/18/98	1439	39.16	78.4	8.03	1230	0	0.3	0.2	520	-138	<50	0.3	420	0%	4.35
HGRK-PRTMWD14	3/18/98	1119	39.30	82.9	8.38	1357	0	0	0	480	-205	65	0.1	380	0%	4.32
HGRK-PRTMWD15	3/18/98	1504	39.37	80.0	7.84	1292	1	0.2	0.2	480	-176	<50	0.2	380	0%	4.36
HGRK-PRTMWD16	3/18/98	1143	38.74	86.8	8.66	1457	0	0	0	520	-213	75	0.1	400	4%	4.41
HGRK-PRTMWD17	3/18/98	0933	39.00	81.9	8.11	1435	1	0	0	540	-210	70	0.4	400	1%	4.44
HGRK-PRTMWD18	3/17/98	1653	39.14	78.6	9.07	1223	0	0	0	420	-207	125	0.2	340	1%	4.64
HGRK-PRTMWD19	3/18/98	1535	39.34	77.5	9.22	1116	0	0	0	420	-158	<50	0.2	380	0%	4.37
HGRK-PRTMWD20	3/18/98	1258	39.41	79.2	7.71	1316	1	0.6	0.5	520	-145	<50	0.3	440	0%	4.35
HGRK-PRTMWI01	3/17/98	1400	19.00	80.7	8.02	340	0	0.4	0.2	188	-83	<50	0.3	180	0%	4.00
HGRK-PRTMWI02	3/17/98	1117	19.42	79.9	9.01	108	1	0	0	24	-191	<50	0.4	40	1%	3.97
HGRK-PRTMWI03	3/17/98	1415	19.05	81.2	7.75	364	0	0.5	0.2	205	-85	<50	0.2	180	0%	4.03
HGRK-PRTMWI05	3/17/98	1219	19.20	83.8	9.42	130	1	0	0	29	-174	<50	0.2	35	2%	4.01
HGRK-PRTMWI07	3/17/98	1032	19.04	77.9	9.97	95	1	0	0	16	-157	<50	0.3	35	0%	4.04
HGRK-PRTMWI09	3/17/98	0938	20.30	78.6	10.34	118	6	0	0	16	-170	<50	0.4	119	3%	4.08
HGRK-PRTMWI11	3/17/98	1438	18.92	79.3	7.70	369	0	0.7	0.3	188	-109	<50	0.2	200	0%	4.11
HGRK-PRTMWI12	3/17/98	1234	20.01	83.0	9.67	146	2	0	0	20	-175	<50	0.3	119	0%	4.10
HGRK-PRTMWI13	3/17/98	1459	19.40	80.6	7.85	474	0	0.6	0	188	-70	<50	0.2	200	0%	4.23
HGRK-PRTMWI14	3/17/98	1252	19.32	82.7	9.12	249	1	0	0	51	-164	<50	0.3	65	3%	4.15
HGRK-PRTMWI15	3/17/98	1427	19.30	79.7	8.62	467	0	0.5	0	205	-131	<50	0.1	200	0%	4.15
HGRK-PRTMWI16	3/17/98	1318	19.88	82.1	8.45	398	1	0	0	120	-141	<50	0.2	140	22%	4.13
HGRK-PRTMWI17	3/17/98	1057	19.04	79.2	7.92	714	2	0.5	0.5	274	-126	<50	0.3	220	71%	4.15
HGRK-PRTMWI18	3/17/98	1009	19.02	77.9	9.52	529	3	0	0	160	-170	<50	0.3	110	1%	4.14
HGRK-PRTMWI19	3/17/98	1550	19.00	78.3	9.13	414	3	0.4	0	171	-164	<50	0.1	180	6%	4.21
HGRK-PRTMWI20	3/17/98	1341	19.21	82.5	8.86	710	2	0.5	0.2	257	126	<50	0.4	240	2%	4.24

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Total Well Depth (ft. bls)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)	Depth to Water (ft. below TOC)
HGRK-PRTMWD01	4/15/98	1048	39.02	82.3	7.17	1230	2	0.6	0.3	500	-113	<50	0.4	440	2%	5.61
HGRK-PRTMWD02	4/14/98	1608	39.68	81.0	6.49	1282	2	0	0	460	-154	<50	0.2	400	5%	5.35
HGRK-PRTMWD03	4/15/98	1114	39.45	84.3	7.11	1198	1	0	0	460	-109	<50	0.4	460	3%	5.28
HGRK-PRTMWD05	4/14/98	1633	39.51	81.8	6.46	1378	1	0.5	0.6	520	-149	<50	0.2	440	13%	6.38
HGRK-PRTMWD07	4/14/98	1506	39.54	83.8	6.42	1145	7	1.8	0.5	320	-166	<50	0.3	240	6%	6.41
HGRK-PRTMWD09	4/14/98	1420	39.38	83.8	6.51	1180	1	0	0.2	380	-170	<50	0.4	320	19%	5.38
HGRK-PRTMWD11	4/15/98	1140	38.81	82.7	7.26	1235	1	0.4	0	460	-98	<50	0.3	400	4%	4.66
HGRK-PRTMWD12	4/14/98	1659	39.82	78.9	6.81	1251	1	NC	NC	NC	NC	NC	0.3	NC	5%	6.11
HGRK-PRTMWD13	4/15/98	1252	39.16	89.5	7.17	1245	2	0.4	0.2	NC	NC	NC	0.5	NC	0%	4.72
HGRK-PRTMWD14	4/15/98	938	39.30	78.6	7.52	1289	0	0	0	480	-222	65	0.4	320	2%	5.28
HGRK-PRTMWD15	4/15/98	1315	39.37	89.5	7.30	1302	1	0	0	480	-171	<50	0.2	380	2%	NC
HGRK-PRTMWD16	4/15/98	1000	38.74	82.9	7.37	1375	0	0	0	480	-214	<50	0.3	360	4%	5.60
HGRK-PRTMWD17	4/14/98	1440	39.00	82.4	6.57	1495	1	0	0	540	-189	<50	0.2	400	1%	5.40
HGRK-PRTMWD18	4/14/98	1446	39.14	81.6	6.47	1306	1	0	0	440	-189	80	0.3	320	1%	6.30
HGRK-PRTMWD19	4/15/98	1339	39.34	84.8	7.19	1146	1	0	0	400	-116	<50	0.2	400	1%	NC
HGRK-PRTMWD20	4/15/98	1022	39.41	80.9	7.33	1277	1	0.5	0.2	480	-145	<50	0.5	440	0%	5.34
HGRK-PRTMWI01	4/14/98	1133	19.00	82.7	5.34	352	1	0.6	0.4	205	-109	<50	0.2	180	0%	4.68
HGRK-PRTMWI02	4/13/98	1641	19.42	77.4	6.68	94	2	0	0	28	-170	<50	0.5	30	0%	4.60
HGRK-PRTMWI03	4/14/98	1154	19.05	82.6	5.28	364	1	0.7	0.6	188	-108	<50	0.2	160	0%	4.70
HGRK-PRTMWI05	4/14/98	933	19.20	78.8	7.22	119	1	0	0	24	-179	<50	0.4	35	0%	4.67
HGRK-PRTMWI07	4/13/98	1604	19.04	79.9	6.90	80	1	0	0	21	-181	<50	0.8	30	0%	4.56
HGRK-PRTMWI09	4/13/98	1525	20.30	81.4	6.94	111	9	0	0	16	-130	<50	0.9	34	13%	4.67
HGRK-PRTMWI11	4/14/98	1210	18.92	82.2	5.40	382	1	0.7	0.7	205	-125	<50	0.4	205	0%	4.78
HGRK-PRTMWI12	4/14/98	951	20.01	78.4	6.65	143	2	0	0	17	-182	<50	0.4	35	0%	4.77
HGRK-PRTMWI13	4/14/98	1225	19.40	83.5	5.74	466	1	0.4	0.4	205	-122	<50	0.4	160	0%	4.94
HGRK-PRTMWI14	4/14/98	1015	19.32	79.8	6.07	222	2	0	0	51	-186	<50	0.3	55	2%	4.82
HGRK-PRTMWI15	4/14/98	1331	19.30	84.9	5.65	502	1	0.4	0.6	188	-120	<50	0.2	180	2%	4.84
HGRK-PRTMWI16	4/14/98	1042	19.88	81.1	6.22	288	2	0	0	68	-197	<50	0.3	80	372%	4.86
HGRK-PRTMWI17	4/13/98	1020	19.04	80.0	6.79	624	3	0.6	0.7	274	-114	<50	0.4	260	160%	4.96
HGRK-PRTMWI18	4/13/98	1546	19.02	80.5	6.99	379	2	0	0	137	-171	<50	0.4	180	3%	4.87
HGRK-PRTMWI19	4/14/98	1349	19.00	84.5	5.93	431	2	0.2	0	154	-147	<50	0.3	160	2%	4.94
HGRK-PRTMWI20	4/14/98	1104	19.21	83.1	6.09	801	4	1.0	1.0	291	-128	<50	0.2	300	132%	4.98

NC = Not Collected

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Total Well Depth (ft. bls)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)	Depth to Water (ft. below TOC)
HGRK-PRTMWD01	5/20/98	1548	39.00	87.8	7.40	1204	3	0.7	0.6	479	-130	<50	0.4	420	0%	6.17
HGRK-PRTMWD02	5/20/98	1250	39.68	87.4	7.88	1180	2	0	0.4	428	-146	<50	0.3	380	0%	6.04
HGRK-PRTMWD03	5/20/98	1612	39.45	89.5	7.67	1238	1	0	0	479	-91	<50	0.3	460	0%	6.17
HGRK-PRTMWD05	5/20/98	1314	39.51	90.8	7.50	1326	1	0.6	0.4	496	-128	<50	0.3	400	0%	6.66
HGRK-PRTMWD07	5/20/98	1104	39.54	88.7	8.29	1049	16	1.9	0.2	325	-105	<50	0.2	220	18%	6.79
HGRK-PRTMWD09	5/20/98	1004	38.34	85.7	7.56	880	4	0	0	410	-116	<50	0.3	360	1%	6.10
HGRK-PRTMWD11	5/21/98	948	38.80	84	7.62	1166	1	0.5	0.4	445	-79	<50	NC	400	0%	6.03
HGRK-PRTMWD12	5/20/98	1342	39.82	89.5	7.96	1174	0	0	0	342	-185	<50	0.3	200	0%	5.81
HGRK-PRTMWD13	5/21/98	1009	39.28	84.9	7.60	1147	1	0.4	0.4	462	-121	<50	NC	400	0%	5.93
HGRK-PRTMWD14	5/20/98	1410	39.29	88.2	8.00	1318	0	0	0	496	-184	60	0.3	320	1%	5.94
HGRK-PRTMWD15	5/21/98	1035	39.37	86.4	7.54	1204	1	0	0	479	-145	<50	NC	400	0%	5.88
HGRK-PRTMWD16	5/20/98	1454	38.71	87.8	8.04	1407	1	0	0	564	-205	<50	0.3	320	1%	6.20
HGRK-PRTMWD17	5/20/98	1130	38.99	89.8	7.82	1356	1	0	0	547	-195	<50	0.2	420	0%	6.07
HGRK-PRTMWD18	5/20/98	1035	39.14	87.5	8.51	1159	2	0	0	445	-186	60	0.2	360	0%	6.71
HGRK-PRTMWD19	5/21/98	1100	39.34	85.8	8.10	1040	1	0	0	376	-113	<50	NC	340	0%	6.00
HGRK-PRTMWD20	5/20/98	1522	39.69	85.4	7.40	1254	1	0.4	0.4	496	-129	<50	0.3	400	0%	5.92
HGRK-PRTMWI01	5/19/98	1433	18.99	83.9	7.67	337	0	0.6	0.7	171	-112	<50	0.2	180	0%	5.38
HGRK-PRTMWI02	5/19/98	1114	19.41	84.7	9.52	113	2	0	0	25	-145	<50	0.4	40	0%	5.33
HGRK-PRTMWI03	5/19/98	1458	19.05	84.3	7.62	348	0	0.5	0.2	171	-101	<50	0.2	180	0%	5.70
HGRK-PRTMWI05	5/19/98	1136	19.19	86.2	9.67	101	1	0	0	24	-157	<50	0.2	35	0%	5.40
HGRK-PRTMWI07	5/19/98	1029	19.03	85.2	10.22	96	4	0	0	16	-156	<50	0.8	35	0%	5.41
HGRK-PRTMWI09	5/19/98	947	20.29	83.4	10.44	128	10	0	0	137	-172	<50	0.4	180	6%	5.40
HGRK-PRTMWI11	5/19/98	1518	18.92	84.2	7.62	353	0	0.7	0.6	188	-108	<50	0.2	180	0%	5.48
HGRK-PRTMWI12	5/19/98	1251	20.08	82.1	9.63	122	1	0	0	17	-139	<50	0.6	35	0%	5.50
HGRK-PRTMWI13	5/19/98	1537	19.37	84.1	7.75	422	0	0.5	0.1	188	-89	<50	0.2	200	0%	5.66
HGRK-PRTMWI14	5/19/98	1312	18.32	81.5	9.27	192	2	0	0	41	-166	<50	0.2	65	0%	5.58
HGRK-PRTMWI15	5/19/98	1404	19.28	86.6	7.64	455	0	0.6	0.3	188	-103	<50	0.2	220	0%	5.54
HGRK-PRTMWI16	5/19/98	1332	19.56	85.3	9.35	215	2	0	0	34	-104	<50	0.2	65	29%	5.83
HGRK-PRTMWI17	5/19/98	1050	19.30	84.2	10.55	598	3	0.5	0.6	239	-136	<50	0.4	240	349%	5.70
HGRK-PRTMWI18	5/19/98	1013	19.01	82.6	8.85	374	1	0	0	17	-153	<50	0.5	35	0%	5.57
HGRK-PRTMWI19	5/19/98	1626	18.99	85.8	8.66	391	4	0.5	0	137	-129	<50	0.2	160	0%	5.63
HGRK-PRTMWI20	5/19/98	1401	19.21	85.2	7.37	890	5	2.0	1.1	342	-99	<50	0.4	380	9%	5.78

NC = Not Collected

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Depth to Water (ft. below TOC)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)
HGRK-PRTMWD01	6/17/98	1239	7.03	83.9	7.84	1125	1	0.9	0.6	496	-106	<50	NC	460	0%
HGRK-PRTMWD02	6/17/98	942	6.85	83.0	7.99	1083	1	0.2	0.4	445	-165	<50	NC	380	2%
HGRK-PRTMWD03	6/17/98	1302	7.02	85.7	8.18	1165	0	0.4	0.4	462	-105	<50	NC	460	1%
HGRK-PRTMWD05	6/17/98	1005	7.33	84.2	7.73	1205	1	0.8	0.6	530	-130	<50	NC	420	1%
HGRK-PRTMWD07	6/16/98	1650	7.29	83.8	8.58	1002	4	2	0	291	-104	<50	NC	240	5%
HGRK-PRTMWD09	6/16/98	1551	6.55	83.1	7.91	1115	1	0	0	428	-146	<50	NC	380	3%
HGRK-PRTMWD11	6/17/98	1324	7.81	82.7	8.34	1071	1	0.5	0	496	-89	<50	NC	440	1%
HGRK-PRTMWD12	6/17/98	1032	6.42	82.5	8.24	1043	0	0	0	359	-192	<50	NC	220	3%
HGRK-PRTMWD13	6/17/98	1350	6.62	83.2	8.04	1062	0	0.4	0.4	462	-110	<50	NC	400	1%
HGRK-PRTMWD14	6/17/98	1114	6.59	83.7	8.23	1204	0	0	0	513	-196	<50	NC	340	3%
HGRK-PRTMWD15	6/17/98	1414	6.54	86.1	7.73	1141	1	0	0	479	-145	<50	NC	400	1%
HGRK-PRTMWD16	6/17/98	1140	6.73	86.4	7.89	1366	0	0	0	599	-187	<50	NC	440	14%
HGRK-PRTMWD17	6/17/98	917	6.78	84.5	7.81	1262	1	0.2	0	530	-205	<50	NC	380	1%
HGRK-PRTMWD18	6/16/98	1618	7.12	83.4	8.96	1239	1	0	0	513	-176	<50	NC	360	1%
HGRK-PRTMWD19	6/17/98	1442	6.66	83.8	8.02	976	1	0	0	410	-93	<50	NC	360	1%
HGRK-PRTMWD20	6/17/98	1157	6.52	83.7	7.60	1151	0	0.5	0.6	496	-159	<50	NC	440	1%
HGRK-PRTMWI01	6/16/98	1332	5.99	84.1	7.82	330	0	0.6	0.4	171	-69	<50	NC	180	1%
HGRK-PRTMWI02	6/16/98	1054	6.01	85.6	9.72	111	1	0	0	16	-148	<50	NC	35	1%
HGRK-PRTMWI03	6/16/98	1355	6.03	84.6	7.82	340	0	0.4	0.4	171	-92	<50	NC	180	1%
HGRK-PRTMWI05	6/16/98	1111	6.02	84.0	9.80	103	1	0	0	24	-151	<50	NC	35	1%
HGRK-PRTMWI07	6/16/98	1017	6.05	84.2	10.47	115	3	0	0	15	-142	<50	NC	35	1%
HGRK-PRTMWI09	6/16/98	948	6.03	84.4	10.61	131	6	0	0	15	-146	<50	NC	35	5%
HGRK-PRTMWI11	6/16/98	1414	6.10	83.8	7.82	347	0	0.7	0.4	171	-94	<50	NC	180	1%
HGRK-PRTMWI12	6/16/98	1133	6.12	83.1	9.64	131	1	0	0	19	-144	<50	NC	35	1%
HGRK-PRTMWI13	6/16/98	1430	6.27	84.1	7.92	413	0	0.5	0.4	188	-116	<50	NC	200	1%
HGRK-PRTMWI14	6/16/98	1207	6.19	83.1	9.50	190	2	0	0	43	-146	<50	NC	60	2%
HGRK-PRTMWI15	6/16/98	1454	6.16	83.5	7.75	447	0	0.7	0.5	188	-116	<50	NC	220	1%
HGRK-PRTMWI16	6/16/98	1251	6.23	83.8	9.34	246	2	0	0	47	-148	<50	NC	65	22%
HGRK-PRTMWI17	6/16/98	1029	6.30	84.3	8.16	409	2	0.4	0	188	-109	<50	NC	140	244%
HGRK-PRTMWI18	6/16/98	1002	6.19	84.8	8.70	391	2	0	0	154	-119	<50	NC	180	1%
HGRK-PRTMWI19	6/16/98	1512	6.23	83.6	8.80	389	2	0.4	0	154	-129	<50	NC	160	1%
HGRK-PRTMWI20	6/16/98	1312	6.38	84.5	7.41	910	5	2.6	2.0	359	-117	<50	NC	440	6%

Note: Dissolved Oxygen meter malfunctioned during the June 1998 sampling event. No D.O. data available for June 1998.
NC = Not Collected

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Depth to Water (ft. below TOC)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)
HGRK-PRTMWD01	7/16/98	1107	5.49	82.6	7.98	1169	1	0.9	0.6	479	-120	<50	0.5	440	0%
HGRK-PRTMWD02	7/15/98	912	6.10	82.6	5.30	1118	1	0	0.2	410	-164	<50	NC	380	0%
HGRK-PRTMWD03	7/16/98	1137	6.51	84.7	8.00	1224	0	0.2	0	496	-84	<50	0.5	440	0%
HGRK-PRTMWD05	7/15/98	931	7.77	83.6	7.72	1249	1	0.6	0.5	462	-114	<50	NC	380	0%
HGRK-PRTMWD07	7/14/98	1654	7.99	85.8	6.87	1102	2	0.2	0.6	393	-138	<50	NC	220	0%
HGRK-PRTMWD09	7/14/98	1610	6.53	86.8	6.31	1090	2	0	0	410	-136	<50	NC	360	0%
HGRK-PRTMWD11	7/16/98	1257	6.36	83.5	7.97	1130	0	0.4	0.2	462	-106	<50	0.4	400	0%
HGRK-PRTMWD12	7/15/98	958	6.49	81.2	7.44	1083	1	0	0	342	-190	<50	NC	180	4%
HGRK-PRTMWD13	7/16/98	1322	6.20	84.1	7.77	1118	0	0.4	0.2	462	-103	<50	0.7	420	0%
HGRK-PRTMWD14	7/15/98	1207	5.97	81.1	7.79	1234	1	0	0	513	-186	<50	0.6	320	0%
HGRK-PRTMWD15	7/16/98	1347	6.13	88.1	7.62	1031	0	0	0	513	-142	<50	0.6	380	0%
HGRK-PRTMWD16	7/16/98	1016	6.41	86.2	8.28	1020	1	0	0	564	-166	<50	2.2	380	29%
HGRK-PRTMWD17	7/15/98	851	6.74	82.6	3.92	1358	1	0	0	513	-211	<50	NC	400	0%
HGRK-PRTMWD18	7/14/98	1631	7.04	86.9	7.87	1326	1	0	0	564	-167	<50	NC	340	0%
HGRK-PRTMWD19	7/16/98	1414	6.29	83.5	7.96	882	0	0	0	393	-52	<50	0.7	380	0%
HGRK-PRTMWD20	7/16/98	1042	6.29	82.9	7.88	1187	0	0.4	0.2	513	-152	<50	0.8	400	0%
HGRK-PRTMWI01	7/14/98	1420	5.89	88.2	6.15	333	0	0.5	0.4	100	-110	<50	NC	160	0%
HGRK-PRTMWI02	7/14/98	1125	5.96	86.0	9.29	106	1	0	0	17	-145	<50	NC	35	0%
HGRK-PRTMWI03	7/14/98	1434	5.94	87.5	6.19	342	1	0.5	0.5	171	-106	<50	NC	180	0%
HGRK-PRTMWI05	7/14/98	1141	5.90	85.9	9.20	101	1	0	0	20	-144	<50	NC	30	0%
HGRK-PRTMWI07	7/14/98	1042	5.82	85.9	10.39	123	3	0	0	14	-115	<50	NC	30	38%
HGRK-PRTMWI09	7/14/98	1009	5.90	84.5	9.51	134	5	0	0	14	-145	<50	NC	30	0%
HGRK-PRTMWI11	7/14/98	1453	6.00	88.4	6.10	347	0	0.5	0.6	188	-109	<50	NC	180	0%
HGRK-PRTMWI12	7/14/98	1258	5.97	88.3	8.42	138	1	0	0	21	-92	<50	NC	35	0%
HGRK-PRTMWI13	7/14/98	1514	6.07	89.3	6.33	410	1	0.5	0.4	171	-137	<50	NC	180	0%
HGRK-PRTMWI14	7/14/98	1323	6.01	89.7	8.20	193	3	0	0	37	-154	<50	NC	60	1%
HGRK-PRTMWI15	7/14/98	1528	6.07	88.4	7.29	433	0	0.5	0.4	205	-133	<50	NC	200	0%
HGRK-PRTMWI16	7/14/98	1341	6.04	87.8	8.74	238	1	0	0	41	-166	<50	NC	65	122%
HGRK-PRTMWI17	7/14/98	1104	6.15	85.2	7.31	334	2	0	0	103	-126	<50	NC	120	241%
HGRK-PRTMWI18	7/14/98	1023	6.02	85.6	8.49	335	2	0	0	102	-156	<50	NC	140	2%
HGRK-PRTMWI19	7/14/98	1547	6.14	87.7	6.79	389	1	0.4	0.2	154	-108	<50	NC	160	5%
HGRK-PRTMWI20	7/14/98	1358	6.26	87.9	6.98	935	3	3.1	2.1	400	-116	<50	NC	380	141%

NC = Not Collected

Note: Dissolved Oxygen meter malfunctioned during the July 1998 sampling event.

2.2 The DO reading for this sampling event is believed to be in error since it is an order of magnitude higher than other results in this well.

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Total Well Depth (ft bls)	Depth to Water (ft. below TOC)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)
HGRK-PRTMWD01	8/13/98	1027	39.15	6.19	82.7	7.79	1173	2	1.2	0.4	496	-120	0.2	460	0%
HGRK-PRTMWD02	8/12/98	1542	39.79	6.14	85.6	7.92	1028	0.9	0.2	0.2	427	-162	0.4	360	0%
HGRK-PRTMWD03	8/13/98	1100	39.44	6.19	84.8	7.96	1248	0.71	0.2	0.2	479	-104	0.2	440	0%
HGRK-PRTMWD05	8/12/98	1604	39.51	6.18	87	7.55	1145	0.95	0.6	0.6	496	-140	0.4	440	3%
HGRK-PRTMWD07	8/12/98	1453	39.69	6.17	86.6	8.31	1049	7.42	2.3	1	359	-196	0.6	260	32%
HGRK-PRTMWD09	8/12/98	1325	38.45	6.17	87.5	7.68	1032	0.91	0	0	427	-163	0.5	380	2%
HGRK-PRTMWD11	8/13/98	1127	38.93	6.26	83	7.91	1136	0.95	0.2	0.2	479	-113	0.2	440	0%
HGRK-PRTMWD12	8/13/98	847	39.95	6.17	81.3	8.06	1071	1	0	0	393	-146	0.6	200	0%
HGRK-PRTMWD13	8/13/98	1238	39.45	6.44	84.6	7.66	1102	0.9	0.4	0.2	462	-101	0.3	420	0%
HGRK-PRTMWD14	8/13/98	911	39.43	6.23	82.1	8.11	1272	0.7	0	0	513	-198	0.4	320	3%
HGRK-PRTMWD15	8/13/98	1304	39.51	6.27	87.4	7.54	1777	0.93	0	0	380	-154	0.3	400	0%
HGRK-PRTMWD16	8/13/98	935	38.82	6.31	85.5	7.71	1580	0.96	0.6	0.4	684	-109	0.2	410	5%
HGRK-PRTMWD17	8/13/98	1517	39.11	6.27	85.9	7.68	1290	0.74	0	0	581	-210	0.3	460	0%
HGRK-PRTMWD18	8/12/98	1418	39.28	3.29	86.2	8.15	1310	1.03	0	0	633	-209	0.4	460	1%
HGRK-PRTMWD19	8/13/98	1332	39.47	6.37	84.5	7.83	1119	0.8	0	0	427	-147	0.2	360	0%
HGRK-PRTMWD20	8/13/98	1000	39.8	6.29	82.7	7.61	1222	0.57	0.4	0.4	462	-158	0.2	410	1%
HGRK-PRTMWI01	8/12/98	917	19.14	6.12	86	7.66	312	0.58	0.6	0.6	171	-86	0.5	180	0%
HGRK-PRTMWI02	8/11/98	1446	19.53	6.06	86.6	9.79	115	2.12	0	0	21	-142	0.5	35	0%
HGRK-PRTMWI03	8/12/98	938	19.18	6.13	85	7.71	317	0.58	0.7	0.6	171	-96	0.5	180	0%
HGRK-PRTMWI05	8/11/98	1515	19.3	6.09	86.2	9.69	114	1.57	0	0	26	-132	0.4	35	0%
HGRK-PRTMWI07	8/11/98	1354	19.16	6.12	89.3	10.65	133	2.43	0	0	16	-106	0.5	35	0%
HGRK-PRTMWI09	8/11/98	1250	20.42	6.12	88.6	10.8	143	4.27	0	0	16	-109	0.5	40	0%
HGRK-PRTMWI11	8/12/98	955	19.02	6.2	85.1	7.79	317	0.48	0.7	0.5	171	-86	0.6	180	0%
HGRK-PRTMWI12	8/11/98	1539	22.2	6.18	85.7	9.32	137	0.69	0	0	20	-93	0.6	35	0%
HGRK-PRTMWI13	8/12/98	1023	19.42	6.24	85.9	7.83	369	0.52	0.6	0.7	188	-151	0.5	200	0%
HGRK-PRTMWI14	8/11/98	1601	18.47	6.21	86.9	9.43	185	2.84	0	0	39	-175	0.5	60	1%
HGRK-PRTMWI15	8/12/98	1040	19.41	6.24	85.9	7.67	396	0.6	0.8	0.7	205	-127	0.6	200	0%
HGRK-PRTMWI16	8/11/98	1619	19.67	6.2	86.2	9.21	217	2.48	0	0	41	-172	0.5	60	105%
HGRK-PRTMWI17	8/11/98	1420	19.4	6.22	87.7	8.55	315	1.97	0	0	103	-146	0.6	25	71%
HGRK-PRTMWI18	8/11/98	1321	19.15	6.19	88.5	9.3	360	1.8	0	0	86	-138	0.6	110	0%
HGRK-PRTMWI19	8/12/98	1110	19.12	6.32	86.1	8.37	359	1.07	0.5	0.2	154	-134	0.3	180	46%
HGRK-PRTMWI20	8/11/98	1640	19.33	6.29	86.6	7.23	827	3.61	2.5	2.1	363	-139	0.5	400	3%

NOTES: 3.29 The water level recorded for well HGRK-PRTMWD18 is thought to be in error by -3 feet.

TABLE 4-7
FIELD PARAMETER MEASURMENTS

Well Number	Sample Date	Sample Time	Depth to Water (ft. below TOC)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)
HGRK-PRTMWD01	8/27/98	1033	5.75	82.8	7.98	1112	NC	NC	NC	NC	NC	NC	NC	NC	2%
HGRK-PRTMWD02	8/26/98	1515	5.65	87	7.89	1453	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWD03	8/27/98	1057	5.74	85.2	8.14	1172	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWD05	8/26/98	1603	6.03	87.3	7.61	1252	NC	NC	NC	NC	NC	NC	NC	NC	3%
HGRK-PRTMWD07	8/26/98	1432	6.23	86	8.27	1168	NC	NC	NC	NC	NC	NC	NC	NC	12%
HGRK-PRTMWD09	8/26/98	1351	5.68	85.4	7.72	1134	NC	NC	NC	NC	NC	NC	NC	NC	4%
HGRK-PRTMWD11	8/27/98	1120	5.72	83.3	8.12	1179	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWD12	8/27/98	905	5.65	82.2	8.05	1058	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWD13	8/27/98	1142	5.85	83.7	7.84	1079	NC	NC	NC	NC	NC	NC	NC	NC	0%
HGRK-PRTMWD14	8/27/98	921	5.8	82.9	8.1	1222	NC	NC	NC	NC	NC	NC	NC	NC	7%
HGRK-PRTMWD15	8/27/98	1212	5.75	87	7.72	1202	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWD16	8/27/98	942	5.87	85.8	7.7	1549	NC	NC	NC	NC	NC	NC	NC	NC	10%
HGRK-PRTMWD17	8/26/98	1456	5.81	86.5	7.71	1450	NC	NC	NC	NC	NC	NC	NC	NC	0%
HGRK-PRTMWD18	8/26/98	1412	6.03	85.4	8.07	1472	NC	NC	NC	NC	NC	NC	NC	NC	3%
HGRK-PRTMWD19	8/27/98	1236	5.86	84	8.09	1045	NC	NC	NC	NC	NC	NC	NC	NC	0%
HGRK-PRTMWD20	8/27/98	1002	5.81	83.1	7.97	1151	NC	NC	NC	NC	NC	NC	NC	NC	0%
HGRK-PRTMWI01	8/26/98	1151	5.52	87.6	7.77	351	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWI02	8/26/98	952	5.48	85.2	9.68	114	NC	NC	NC	NC	NC	NC	NC	NC	0%
HGRK-PRTMWI03	8/26/98	1207	5.54	88.3	7.74	356	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWI05	8/26/98	1016	5.51	85.8	9.79	102	NC	NC	NC	NC	NC	NC	NC	NC	4%
HGRK-PRTMWI07	8/26/98	908	5.65	84.9	10.39	119	NC	NC	NC	NC	NC	NC	NC	NC	0%
HGRK-PRTMWI09	8/25/98	1451	5.57	85.1	10.55	138	NC	NC	NC	NC	NC	NC	NC	NC	2%
HGRK-PRTMWI11	8/26/98	1235	5.61	89.5	7.78	361	NC	NC	NC	NC	NC	NC	NC	NC	0%
HGRK-PRTMWI12	8/26/98	1032	5.61	85.4	9.35	140	NC	NC	NC	NC	NC	NC	NC	NC	2%
HGRK-PRTMWI13	8/26/98	1254	5.65	87.9	7.83	411	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWI14	8/26/98	1048	5.63	86.4	9.53	185	NC	NC	NC	NC	NC	NC	NC	NC	6%
HGRK-PRTMWI15	8/26/98	1311	5.67	87.5	7.68	436	NC	NC	NC	NC	NC	NC	NC	NC	1%
HGRK-PRTMWI16	8/26/98	1103	5.65	86.4	9.51	210	NC	NC	NC	NC	NC	NC	NC	NC	43%
HGRK-PRTMWI17	8/26/98	928	5.72	84.6	8.46	331	NC	NC	NC	NC	NC	NC	NC	NC	105%
HGRK-PRTMWI18	8/25/98	1514	5.73	86.2	9.39	314	NC	NC	NC	NC	NC	NC	NC	NC	6%
HGRK-PRTMWI19	8/26/98	1325	6.74	87.3	8.01	398	NC	NC	NC	NC	NC	NC	NC	NC	35%
HGRK-PRTMWI20	8/26/98	1127	5.75	87.6	7.45	776	NC	NC	NC	NC	NC	NC	NC	NC	0%

NC = Not Collected

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Depth to Water (ft. below TOC)	Water Temperature (°F)	pH (S.U.) (see Note below)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)
HGRK-PRTMWD01	9/16/98	1646	4.34	81.4	9.67	1302	1	1.0	0.9	479	-163	<50	NC	460	0%
HGRK-PRTMWD02	9/16/98	1324	4.45	82.7	9.29	1135	1	0.2	0.2	427	-195	<50	NC	380	0%
HGRK-PRTMWD03	9/16/98	1720	4.38	83.6	9.6	1363	1	NC	NC	NC	NC	NC	NC	NC	0%
HGRK-PRTMWD05	9/16/98	1352	4.72	84.7	7.75	1269	1	0.7	0	462	-84	<50	NC	400	0%
HGRK-PRTMWD07	9/16/98	1240	4.81	83.3	9.01	1179	5	2.6	1	393	-180	<50	NC	260	0%
HGRK-PRTMWD09	9/15/98	1602	5.03	83.3	7.77	1078	1	NC	NC	NC	NC	NC	NC	NC	2%
HGRK-PRTMWD11	9/16/98	1752	4.42	80.8	10.88	1260	1	0.5	0.4	445	-125	<50	NC	400	0%
HGRK-PRTMWD12	9/16/98	1416	4.37	82.9	8.17	1132	1	0.2	0	342	-197	<50	NC	400	8%
HGRK-PRTMWD13	9/16/98	1824	4.52	80.6	15.94	1248	1	0.4	0.4	427	-113	<50	NC	400	0%
HGRK-PRTMWD14	9/16/98	1440	4.52	83.3	8.28	1425	1	0	0	530	-228	<50	NC	320	7%
HGRK-PRTMWD15	9/16/98	1852	4.41	83.2	15.97	1385	1	0	0	479	-151	<50	NC	400	0%
HGRK-PRTMWD16	9/16/98	1506	4.52	86	8.76	1846	1	0.4	0.4	752	-193	<50	NC	420	6%
HGRK-PRTMWD17	9/16/98	1300	4.59	83.6	8.25	1481	1	0	0	633	-218	<50	NC	480	0%
HGRK-PRTMWD18	9/15/98	1620	5.25	82.6	8.12	1464	1	0	0	701	-202	<50	NC	460	0%
HGRK-PRTMWD19	9/16/98	1914	4.51	81.3	15.90	1234	NC	0	0	410	-166	<50	NC	420	0%
HGRK-PRTMWD20	9/16/98	1542	4.44	82.2	10.38	1366	1	0.2	0.2	496	-131	<50	NC	380	0%
HGRK-PRTMWI01	9/15/98	1357	4.87	87.3	7.82	356	0	0.5	0	154	-89	<50	NC	180	0%
HGRK-PRTMWI02	9/15/98	1140	4.95	86.2	9.69	118	1	0	0	21	-116	<50	NC	40	0%
HGRK-PRTMWI03	9/15/98	1412	4.97	86.9	7.82	343	0	0.5	0.4	171	-98	<50	NC	180	0%
HGRK-PRTMWI05	9/15/98	1159	4.89	86.1	9.85	108	1	0	0	21	-135	<50	NC	35	6%
HGRK-PRTMWI07	9/15/98	1100	4.90	86.6	10.33	120	1	0	0	20	-104	<50	NC	35	0%
HGRK-PRTMWI09	9/15/98	1025	4.98	85.6	10.57	137	4	0.4	0	15	-99	<50	NC	35	7%
HGRK-PRTMWI11	9/15/98	1437	4.99	86.2	7.77	355	0	0.6	0.4	171	-102	<50	NC	180	0%
HGRK-PRTMWI12	9/15/98	1210	5.00	85.6	9.47	137	1	0	0	22	-118	<50	NC	40	2%
HGRK-PRTMWI13	9/15/98	1456	4.97	86.3	7.93	397	1	0.5	0.5	188	-146	<50	NC	180	0%
HGRK-PRTMWI14	9/15/98	1244	5.08	86.5	9.56	178	2	0	0	33	-136	<50	NC	55	9%
HGRK-PRTMWI15	9/15/98	1506	4.98	86.1	8.03	434	1	0.7	0.4	171	-98	<50	NC	180	0%
HGRK-PRTMWI16	9/15/98	1303	5.03	86.3	10.00	207	3	0	0	30	-180	<50	NC	50	47%
HGRK-PRTMWI17	9/15/98	1118	5.03	85.9	8.54	334	2	0	0	85	-101	<50	NC	80	85%
HGRK-PRTMWI18	9/16/98	1926	5.32	84.2	15.88	NC	1	0	0	58	-200	<50	NC	100	1%
HGRK-PRTMWI19	9/15/98	1526	5.09	86.2	8.12	400	1	0.4	0.3	154	-155	<50	NC	160	224%
HGRK-PRTMWI20	9/15/98	1326	5.11	86.5	7.72	709	2	2.0	0.5	256	-111	<50	NC	320	0%

NOTES: 15.88 The pH readings for this event should not be used for comparison with historical data. The readings were sufficient to determine stabilization requirements for well purging, but the samples were collected in rainy conditions and the moisture affected the pH meter to the point that it could not be corrected through re-calibration.

NC = Not Collected

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Depth to Water (ft. below TOC)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)
HGRK-PRTMWD01	10/14/98	1314	4.06	83.8	7.63	1119	0	0.8	0.6	462	-123	<50	0.22	400	0%
HGRK-PRTMWD02	10/14/98	1016	4.15	83.1	7.78	1115	0	0.2	0.2	428	-125	<50	0.58	360	0%
HGRK-PRTMWD03	10/14/98	1338	4.14	85.7	7.59	1189	0	0.5	0.2	496	-104	<50	0.11	440	0%
HGRK-PRTMWD05	10/14/98	1036	4.37	84.8	7.5	1232	0	0.6	0.7	462	-153	<50	0.31	400	38%
HGRK-PRTMWD07	10/14/98	938	4.32	84	8.22	1010	4	2.5	0.2	342	-72	<50	0.56	240	0%
HGRK-PRTMWD09	10/13/98	1633	4.09	83	7.85	1028	1	0	0	359	-138	<50	0.36	300	0%
HGRK-PRTMWD11	10/14/98	1404	4.11	82.6	7.54	1132	0	0.2	0.2	462	-123	<50	0.24	400	0%
HGRK-PRTMWD12	10/14/98	1104	4.05	83.2	8	1121	0	0	0	359	-200	<50	0.22	180	0%
HGRK-PRTMWD13	10/14/98	1434	4.24	82.9	7.8	1110	0	0.3	0.3	428	-121	<50	0.23	380	0%
HGRK-PRTMWD14	10/14/98	1130	4.22	83.3	8.03	1255	0	0	0	564	-221	<50	0.24	320	40%
HGRK-PRTMWD15	10/14/98	1452	4.16	85.5	7.51	1214	0	0	0	513	-188	<50	0.28	400	0%
HGRK-PRTMWD16	10/14/98	1154	4.21	87.2	7.45	1639	1	0.6	0.6	736	-141	<50	0.21	500	0%
HGRK-PRTMWD17	10/14/98	958	4.47	83.5	7.94	1454	0	0.2	0.2	667	-145	<50	0.61	400	1%
HGRK-PRTMWD18	10/13/98	1654	4.21	82.3	8.03	1422	0	0	0	667	-180	<50	0.17	440	25%
HGRK-PRTMWD19	10/14/98	1512	4.26	83	7.9	1095	0	0.4	0.2	410	-145	<50	0.23	360	0%
HGRK-PRTMWD20	10/14/98	1249	4.19	83.9	7.32	1239	0	0.3	0.2	513	-148	<50	0.23	400	1%
HGRK-PRTMWI01	10/13/98	1433	4.01	87.1	7.72	371	0	0.5	0.4	188	-112	<50	0.4	180	0%
HGRK-PRTMWI02	10/13/98	1130	3.84	86.2	9.46	130	0.76	0	0	30	-135	<50	0.33	40	0%
HGRK-PRTMWI03	10/13/98	1452	3.96	86.7	7.79	365	0	0.5	0.2	188	-76	<50	0.32	180	0%
HGRK-PRTMWI05	10/13/98	1148	3.89	86.6	9.79	122	1.28	0	0	21	-166	<50	0.35	40	0%
HGRK-PRTMWI07	10/13/98	1046	3.95	86.4	9.84	130	0.46	0	0	33	-122	<50	0.48	45	0%
HGRK-PRTMWI09	10/13/98	1007	3.93	86	10.53	139	3.92	0	0	17	-130	<50	1.06	35	0%
HGRK-PRTMWI11	10/13/98	1515	4.09	86.1	7.77	374	0	0.7	0.9	188	-135	<50	0.19	180	0%
HGRK-PRTMWI12	10/13/98	1314	4.03	87	9.44	137	1	0	0	21	-101	<50	0.38	35	7%
HGRK-PRTMWI13	10/13/98	1530	4.1	85.7	7.91	405	0	0.3	0.2	171	-80	<50	0.29	180	0%
HGRK-PRTMWI14	10/13/98	1339	4.05	86.9	9.52	175	2	0	0	29	-147	<50	0.4	45	11%
HGRK-PRTMWI15	10/13/98	1552	4.09	85.9	7.85	437	0	0.5	0.7	171	-137	<50	0.44	180	0%
HGRK-PRTMWI16	10/13/98	1354	4.05	86.7	10.87	314	5	0	0	43	-178	<50	0.58	70	98%
HGRK-PRTMWI17	10/13/98	1110	4.09	86	8.42	379	4.03	0	0	86	-157	<50	0.41	120	145%
HGRK-PRTMWI18	10/13/98	1024	4.04	86	10.15	313	1.8	0	0	86	-141	<50	0.43	120	0%
HGRK-PRTMWI19	10/13/98	1606	4.18	85.9	8.21	411	0	0.3	0.2	154	-101	<50	0.26	160	339%
HGRK-PRTMWI20	10/13/98	1410	4.19	86.3	7.43	784	1	2.1	1.9	325	-146	<50	0.32	340	412%

TABLE 4-7
FIELD PARAMETER MEASUREMENTS

Well Number	Sample Date	Sample Time	Depth to Water (ft. below TOC)	Water Temperature (°F)	pH (S.U.)	Electrical Conductivity (umhos/cm)	Turbidity (N.T.U.)	Total Iron (mg/L)	FE (+2) (mg/L)	Hardness (mg/L as $CaCO_3$)	ORP (mv)	Sulfate (mg/L)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Explosimeter (% of L.E.L.)
HGRK-PRTMWD01	11/18/98	1432	4.83	82.8	7.64	1118	1	0.2	0.9	428	-143	<50	0.3	420	0%
HGRK-PRTMWD02	11/18/98	1052	4.68	82.0	7.74	1095	1	0	0.2	410	-170	<50	0.2	360	10%
HGRK-PRTMWD03	11/18/98	1510	4.77	84.5	7.68	1183	1	0.5	0.2	496	-118	<50	0.3	460	0%
HGRK-PRTMWD05	11/18/98	1119	4.99	83.4	7.52	1224	1	0.6	0.6	428	-150	<50	0.2	400	10%
HGRK-PRTMWD07	11/18/98	1002	4.94	82.7	8.19	1005	7	2.4	0.5	342	-160	<50	0.2	220	6%
HGRK-PRTMWD09	11/18/98	907	4.68	82.2	7.53	1044	1	0	0	376	-145	<50	0.2	280	1%
HGRK-PRTMWD11	11/18/98	1546	4.77	81.7	7.66	1116	1	0.4	0.2	479	-113	<50	0.2	400	0%
HGRK-PRTMWD12	11/18/98	1145	4.7	81.3	7.96	1069	1	0	0	325	-188	<50	0.2	160	0%
HGRK-PRTMWD13	11/19/98	954	4.86	83.7	7.5	1022	0	0.4	0.2	445	-73	<50	0.2	380	0%
HGRK-PRTMWD14	11/18/98	1250	4.81	81.9	8.01	1251	0	0	0	496	-197	<50	0.2	300	6%
HGRK-PRTMWD15	11/19/98	1024	4.76	85.8	7.38	1135	1	0	0	462	-178	<50	0.2	380	1%
HGRK-PRTMWD16	11/18/98	1324	4.84	85.6	7.46	1694	1	0.9	0.6	736	-156	<50	0.3	520	25%
HGRK-PRTMWD17	11/18/98	1026	4.9	83.1	7.54	1555	1	0.2	0.2	701	-183	<50	0.3	440	0%
HGRK-PRTMWD18	11/18/98	928	4.94	82.5	7.69	1416	1	0.2	0.2	581	-174	<50	0.2	380	0%
HGRK-PRTMWD19	11/19/98	1054	4.87	84.5	7.57	1029	0	0.2	0.2	393	-152	<50	0.2	380	0%
HGRK-PRTMWD20	11/18/98	1355	4.77	82.8	7.44	1237	0	0.5	0.4	496	167	<50	0.2	360	3%
HGRK-PRTMWI01	11/17/98	1424	4.53	86.2	7.62	330	0	0.6	0.4	171	-69	<50	0.3	160	0%
HGRK-PRTMWI02	11/17/98	1123	4.49	84.8	9.17	122	1	0	0	37	-157	55	0.6	50	0%
HGRK-PRTMWI03	11/17/98	1455	4.55	86.8	7.60	335	0	0.5	0.3	171	-53	<50	0.4	180	0%
HGRK-PRTMWI05	11/17/98	1144	4.57	85.1	9.27	123	0	0	0	31	-133	<50	0.3	45	0%
HGRK-PRTMWI07	11/17/98	1046	4.57	85.0	9.49	114	0	0	0	34	-52	<50	0.6	40	8%
HGRK-PRTMWI09	11/17/98	1014	4.54	85.1	10.28	125	2	0	0	16	-103	<50	0.6	30	27%
HGRK-PRTMWI11	11/17/98	1525	4.61	85.5	7.54	335	0	0.7	0.6	188	-108	<50	0.4	160	0%
HGRK-PRTMWI12	11/17/98	1201	4.64	84.9	9.25	128	0	0	0	24	-75	<50	0.2	45	7%
HGRK-PRTMWI13	11/17/98	1540	4.67	84.9	7.62	351	0	0.5	0.4	171	-120	<50	0.4	160	0%
HGRK-PRTMWI14	11/17/98	1322	4.65	86.9	9.41	148	2	0	0	28	-139	<50	0.2	40	3%
HGRK-PRTMWI15	11/17/98	1604	4.65	85.8	7.54	392	0	0.4	0.6	171	-136	<50	0.4	180	0%
HGRK-PRTMWI16	11/17/98	1334	4.66	86.5	10.74	295	5	0	0	39	-171	<50	0.2	65	58%
HGRK-PRTMWI17	11/17/98	1103	4.69	84.0	8.46	278	1	0	0	68	-154	<50	0.4	100	138%
HGRK-PRTMWI18	11/17/98	1030	4.65	84.7	9.74	243	1	0	0	38	-118	<50	0.6	100	1%
HGRK-PRTMWI19	11/17/98	1624	4.74	85.0	7.82	386	0	0.3	0.2	137	-147	<50	0.2	160	324%
HGRK-PRTMWI20	11/17/98	1400	4.77	86.0	7.41	670	2	2.0	1.3	239	-138	<50	0.2	320	2%

NOTES: 167 The measurement is believed to be in error.

TABLE 4-8
WATER TEMPERATURE SUMMARY

Well No.	WATER TEMPERATURE (°F) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	77.0	78.2	82.3	87.8	82.6	82.6	82.7	81.4	83.8	82.8	82.1	3.0
HGRK-PRTMWD03	79.5	80.0	84.3	89.5	84.7	84.7	84.8	83.6	85.7	84.5	84.1	2.8
HGRK-PRTMWD11	77.4	78.3	82.7	84.0	83.5	83.5	83.0	80.8	82.6	81.7	81.7	2.3
Average for Deep Wells	**78.0**	**78.8**	**83.1**	**87.1**	**83.6**	**83.6**	**83.5**	**81.9**	**84.0**	**83.0**	**82.7**	**2.6**
Standard Deviation	**1.4**	**1.0**	**1.1**	**2.8**	**1.1**	**1.1**	**1.1**	**1.5**	**1.6**	**1.4**	**1.3**	
HGRK-PRTMWI01	80.2	80.7	82.7	83.9	88.2	88.2	86.0	87.3	87.1	86.2	85.1	3.0
HGRK-PRTMWI03	81.0	81.2	82.6	84.3	87.5	87.5	85.0	86.9	86.7	86.8	84.9	2.6
HGRK-PRTMWI11	81.0	79.3	82.2	84.2	88.4	88.4	85.1	86.2	86.1	85.5	84.6	3.0
Average for Intermediate Wells	**80.7**	**80.4**	**82.5**	**84.1**	**88.0**	**88.0**	**85.4**	**86.8**	**86.6**	**86.2**	**84.9**	**2.8**
Standard Deviation	**0.4**	**1.0**	**0.3**	**0.2**	**0.5**	**0.5**	**0.6**	**0.6**	**0.5**	**0.7**	**0.2**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	78.1	81.0	81.0	87.4	82.6	82.6	85.6	82.7	83.1	82.0	82.7	2.7
HGRK-PRTMWD05	80.4	83.9	81.8	90.8	83.6	83.6	87.0	84.7	84.8	83.4	84.4	2.8
HGRK-PRTMWD12	80.6	80.0	78.9	89.5	81.2	81.2	81.3	82.9	83.2	81.3	82.0	2.9
Average for Deep Wells	**79.7**	**81.6**	**80.6**	**89.2**	**82.5**	**82.5**	**84.6**	**83.4**	**83.7**	**82.4**	**83.0**	**2.6**
Standard Deviation	**1.4**	**2.0**	**1.5**	**1.7**	**1.2**	**1.2**	**3.0**	**1.1**	**1.0**	**1.5**	**1.2**	
HGRK-PRTMWI02	87.4	79.9	77.4	84.7	86.0	86.0	86.6	86.2	86.2	84.8	84.5	3.2
HGRK-PRTMWI05	87.1	83.8	78.8	86.2	85.9	85.9	86.2	86.1	86.6	85.1	85.2	2.4
HGRK-PRTMWI12	80.6	83.0	78.4	82.1	88.3	88.3	85.7	85.6	87.0	84.9	84.4	3.3
Average for Intermediate Wells	**85.0**	**82.2**	**78.2**	**84.3**	**86.7**	**86.7**	**86.2**	**86.0**	**86.6**	**84.9**	**84.7**	**2.7**
Standard Deviation	**3.8**	**2.1**	**0.7**	**2.1**	**1.4**	**1.4**	**0.5**	**0.3**	**0.4**	**0.2**	**0.4**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	79.9	79.5	83.8	88.7	85.8	85.8	86.6	83.3	84.0	82.7	84.0	2.9
HGRK-PRTMWI07	89.8	77.9	79.9	85.2	85.9	85.9	89.3	86.6	86.4	85.0	85.2	3.9
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	79.9	79.1	83.8	85.7	86.8	86.8	87.5	83.3	83.0	82.2	83.8	2.9
HGRK-PRTMWI09	89.6	78.6	81.4	83.4	84.5	84.5	88.6	85.6	86.0	85.1	84.7	3.2
Average - all wells for each month	**81.8**	**80.3**	**81.4**	**86.1**	**85.3**	**85.3**	**85.7**	**84.6**	**85.1**	**84.1**	**84.0**	**2.1**
Standard Deviation of individual results from monthly average	**4.2**	**1.9**	**2.1**	**2.6**	**2.2**	**2.2**	**2.1**	**2.0**	**1.6**	**1.7**	**1.2**	

TABLE 4-8
WATER TEMPERATURE SUMMARY

Well No.	WATER TEMPERATURE (°F) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	80.1	78.4	89.5	84.9	84.1	84.1	84.6	80.6	82.9	83.7	83.3	3.1
HGRK-PRTMWD15	82.9	80.0	89.5	86.4	88.1	88.1	87.4	83.2	85.5	85.8	85.7	2.9
HGRK-PRTMWD19	80.2	77.5	84.8	85.8	83.5	83.5	84.5	81.3	83.0	84.5	82.9	2.5
Average for Deep Wells	**81.1**	**78.6**	**87.9**	**85.7**	**85.2**	**85.2**	**85.5**	**81.7**	**83.8**	**84.7**	**83.9**	**2.7**
Standard Deviation	**1.6**	**1.3**	**2.7**	**0.8**	**2.5**	**2.5**	**1.6**	**1.3**	**1.5**	**1.1**	**1.5**	
HGRK-PRTMWI13	81.3	80.6	83.5	84.1	89.3	89.3	85.9	86.3	85.7	84.9	85.1	2.9
HGRK-PRTMWI15	81.7	79.7	84.9	86.6	88.4	88.4	85.9	86.1	85.9	85.8	85.3	2.7
HGRK-PRTMWI19	81.0	78.3	84.5	85.8	87.7	87.7	86.1	86.2	85.9	85.0	84.8	3.2
Average for Intermediate Wells	**81.3**	**79.5**	**84.3**	**85.5**	**88.5**	**88.5**	**86.0**	**86.2**	**85.8**	**85.4**	**85.1**	**2.8**
Standard Deviation	**0.4**	**1.2**	**0.7**	**1.3**	**0.8**	**0.8**	**0.1**	**0.1**	**0.1**	**0.6**	**0.3**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	81.3	82.9	78.6	88.2	81.1	81.1	82.1	83.3	83.3	81.9	82.4	2.5
HGRK-PRTMWD16	84.0	86.8	82.9	87.8	86.2	86.2	85.5	86.0	87.2	85.6	85.8	1.5
HGRK-PRTMWD20	81.0	79.2	80.9	85.4	82.9	82.9	82.7	82.2	83.9	82.8	82.4	1.7
Average for Deep Wells	**82.1**	**83.0**	**80.8**	**87.1**	**83.4**	**83.4**	**83.4**	**83.8**	**84.8**	**83.4**	**83.5**	**1.7**
Standard Deviation	**1.7**	**3.8**	**2.2**	**1.5**	**2.6**	**2.6**	**1.8**	**2.0**	**2.1**	**1.9**	**2.0**	
HGRK-PRTMWI14	82.2	82.7	79.8	81.5	89.7	89.7	86.9	86.5	86.9	86.9	85.3	3.5
HGRK-PRTMWI16	83.8	82.1	81.1	85.3	87.8	87.8	86.2	86.3	86.7	86.5	85.4	2.3
HGRK-PRTMWI20	81.0	82.5	83.1	85.2	87.9	87.9	86.6	86.5	86.3	86.0	85.2	2.5
Average for Intermediate Wells	**82.3**	**82.4**	**81.3**	**84.0**	**88.5**	**88.5**	**86.6**	**86.4**	**86.6**	**86.7**	**85.3**	**2.6**
Standard Deviation	**1.4**	**0.3**	**1.7**	**2.2**	**1.1**	**1.1**	**0.4**	**0.1**	**0.3**	**0.3**	**0.1**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	79.2	81.9	82.4	89.8	82.6	82.6	85.9	83.6	83.5	83.1	83.5	2.8
HGRK-PRTMWI17	88.3	79.2	80.0	84.2	85.2	85.2	87.7	85.9	86.0	84.0	84.6	3.1
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	82.9	78.6	81.6	87.5	86.9	86.9	86.2	82.6	82.3	82.5	83.8	2.9
HGRK-PRTMWI18	88.5	77.9	80.5	82.6	85.6	85.6	88.5	84.2	86.0	84.7	84.4	3.3
Average - all wells for each month	**82.5**	**80.5**	**82.9**	**85.8**	**85.8**	**85.8**	**85.8**	**84.3**	**85.0**	**84.5**	**84.3**	**1.8**
Standard Deviation of individual results from monthly average	**2.8**	**2.6**	**3.3**	**2.1**	**2.5**	**2.5**	**1.7**	**2.0**	**1.7**	**1.7**	**1.2**	

TABLE 4-9
pH SUMMARY

Well No.	pH (Standard Units) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	7.4	7.7	7.2	7.4	7.8	8.0	7.8	Err	7.6	7.6	7.6	0.3
HGRK-PRTMWD03	8.4	8.2	7.1	7.7	8.2	8.0	8.0	Err	7.6	7.7	7.9	0.4
HGRK-PRTMWD11	7.8	7.9	7.3	7.6	8.3	8.0	7.9	Err	7.5	7.7	7.8	0.3
Average for Deep Wells	**7.9**	**8.0**	**7.2**	**7.6**	**8.1**	**8.0**	**7.9**	Err	**7.6**	**7.7**	**7.8**	**0.3**
Standard Deviation	**0.5**	**0.3**	**0.1**	**0.1**	**0.3**	**0.0**	**0.1**	Err	**0.0**	**0.0**	**0.1**	
HGRK-PRTMWI01	7.7	8.0	5.3	7.7	7.8	6.2	7.7	Err	7.7	7.6	7.3	0.9
HGRK-PRTMWI03	7.7	7.8	5.3	7.6	7.8	6.2	7.7	Err	7.8	7.60	7.2	1.0
HGRK-PRTMWI11	7.7	7.7	5.4	7.6	7.8	6.1	7.8	Err	7.8	7.5	7.3	0.9
Average for Intermediate Wells	**7.7**	**7.8**	**5.3**	**7.6**	**7.8**	**6.1**	**7.7**	Err	**7.8**	**7.6**	**7.3**	**0.9**
Standard Deviation	**0.0**	**0.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.1**	Err	**0.0**	**0.1**	**0.0**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	8.3	8.3	6.5	7.9	8.0	5.3	7.9	Err	7.8	7.7	7.5	1.0
HGRK-PRTMWD05	7.7	7.8	6.5	7.5	7.7	7.7	7.6	Err	7.5	7.5	7.5	0.4
HGRK-PRTMWD12	8.1	8.3	6.8	8.0	8.2	7.4	8.1	Err	8.0	8.0	7.9	0.5
Average for Deep Wells	**8.0**	**8.2**	**6.6**	**7.8**	**8.0**	**6.8**	**7.8**	Err	**7.8**	**7.7**	**7.6**	**0.6**
Standard Deviation	**0.3**	**0.3**	**0.2**	**0.2**	**0.3**	**1.3**	**0.3**	Err	**0.3**	**0.2**	**0.2**	
HGRK-PRTMWI02	9.3	9.0	6.7	9.5	9.7	9.3	9.8	Err	9.5	9.2	9.1	0.9
HGRK-PRTMWI05	9.4	9.4	7.2	9.7	9.8	9.2	9.7	Err	9.8	9.3	9.3	0.8
HGRK-PRTMWI12	7.5	9.7	6.7	9.6	9.6	8.4	9.3	Err	9.4	9.3	8.8	1.1
Average for Intermediate Wells	**8.8**	**9.4**	**6.9**	**9.6**	**9.7**	**9.0**	**9.6**	Err	**9.6**	**9.2**	**9.1**	**0.9**
Standard Deviation	**1.1**	**0.3**	**0.3**	**0.1**	**0.1**	**0.5**	**0.2**	Err	**0.2**	**0.1**	**0.2**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	8.7	8.5	6.4	8.3	8.6	6.9	8.3	Err	8.2	8.2	8.0	0.8
HGRK-PRTMWI07	9.4	10.0	6.9	10.2	10.5	10.4	10.7	Err	9.8	9.5	9.7	1.1
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	7.3	7.7	6.5	7.6	7.9	6.3	7.7	Err	7.9	7.5	7.4	0.6
HGRK-PRTMWI09	9.8	10.3	6.9	10.4	10.6	9.5	10.8	Err	10.5	10.3	9.9	1.2
Average - all wells for each month	**8.3**	**8.5**	**6.5**	**8.4**	**8.7**	**7.7**	**8.5**	**Err**	**8.4**	**8.3**	**8.1**	**0.9**
Standard Deviation of individual results from monthly average	**0.8**	**0.9**	**0.7**	**1.1**	**1.0**	**1.5**	**1.1**	**Err**	**1.0**	**0.9**	**0.7**	

Err — Suspected Instrument Malfunction so data not included in average, standard deviation analysis.

TABLE 4-9
pH SUMMARY

Well No.	pH (Standard Units) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	7.9	8.0	7.2	7.6	8.0	7.8	7.7	Err	7.8	7.5	7.7	0.3
HGRK-PRTMWD15	7.6	7.8	7.3	7.5	7.7	7.6	7.5	Err	7.5	7.4	7.6	0.2
HGRK-PRTMWD19	9.4	9.2	7.2	8.1	8.0	8.0	7.8	Err	7.9	7.6	8.1	0.7
Average for Deep Wells	**8.3**	**8.4**	**7.2**	**7.7**	**7.9**	**7.8**	**7.7**	Err	**7.7**	**7.5**	**7.8**	**0.4**
Standard Deviation	**0.9**	**0.7**	**0.1**	**0.3**	**0.2**	**0.2**	**0.1**	Err	**0.2**	**0.1**	**0.3**	
HGRK-PRTMWI13	7.9	7.9	5.7	7.8	7.9	6.3	7.8	Err	7.9	7.6	7.4	0.8
HGRK-PRTMWI15	8.8	8.6	5.7	7.6	7.8	7.3	7.7	Err	7.9	7.5	7.6	0.9
HGRK-PRTMWI19	8.5	9.1	5.9	8.7	8.8	6.8	8.4	Err	8.2	7.8	8.0	1.0
Average for Intermediate Wells	**8.4**	**8.5**	**5.8**	**8.0**	**8.2**	**6.8**	**8.0**	Err	**8.0**	**7.7**	**7.7**	**0.9**
Standard Deviation	**0.5**	**0.6**	**0.1**	**0.6**	**0.6**	**0.5**	**0.4**	Err	**0.2**	**0.1**	**0.3**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	8.6	8.4	7.5	8.0	8.2	7.8	8.1	Err	8.0	8.0	8.1	0.3
HGRK-PRTMWD16	8.8	8.7	7.4	8.0	7.9	8.3	7.7	Err	7.5	7.5	8.0	0.5
HGRK-PRTMWD20	7.6	7.7	7.3	7.4	7.6	7.9	7.6	Err	7.3	7.4	7.5	0.2
Average for Deep Wells	**8.3**	**8.3**	**7.4**	**7.8**	**7.9**	**8.0**	**7.8**	Err	**7.6**	**7.6**	**7.9**	**0.3**
Standard Deviation	**0.7**	**0.5**	**0.1**	**0.4**	**0.3**	**0.3**	**0.3**	Err	**0.4**	**0.3**	**0.3**	
HGRK-PRTMWI14	9.6	9.1	6.1	9.3	9.5	8.2	9.4	Err	9.5	9.4	8.9	1.1
HGRK-PRTMWI16	8.1	8.5	6.2	9.4	9.3	8.7	9.2	Err	10.9	10.7	9.0	1.4
HGRK-PRTMWI20	9.0	8.9	6.1	7.4	7.4	7.0	7.2	Err	7.4	7.4	7.5	0.9
Average for Intermediate Wells	**8.9**	**8.8**	**6.1**	**8.7**	**8.8**	**8.0**	**8.6**	Err	**9.3**	**9.2**	**8.5**	**1.0**
Standard Deviation	**0.8**	**0.3**	**0.1**	**1.1**	**1.2**	**0.9**	**1.2**	Err	**1.7**	**1.7**	**0.8**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	7.7	8.1	6.6	7.8	7.8	3.9	7.7	Err	7.9	7.5	7.2	1.3
HGRK-PRTMWI17	8.0	7.9	6.8	10.6	8.2	7.3	8.6	Err	8.4	8.5	8.2	1.0
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	9.2	9.1	6.5	8.5	9.0	7.9	8.2	Err	8.0	7.7	8.2	0.9
HGRK-PRTMWI18	9.1	9.5	7.0	8.9	8.7	8.5	9.3	Err	10.2	9.7	9.0	0.9
Average - all wells for each month	**8.5**	**8.5**	**6.7**	**8.3**	**8.2**	**7.5**	**8.1**	**Err**	**8.3**	**8.1**	**8.0**	**0.6**
Standard Deviation of individual results from monthly average	**0.7**	**0.6**	**0.6**	**0.9**	**0.6**	**1.1**	**0.7**	**Err**	**1.0**	**1.0**	**0.6**	

Err: Suspected Instrument Malfunction so data not included in average, standard deviation analysis.

TABLE 4-10
ELECTRICAL CONDUCTIVITY SUMMARY

Well No.	ELECTRICAL CONDUCTIVITY (umhos/cm) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	815	1266	1230	1204	1125	1169	1112	1302	1119	1118	1146	134
HGRK-PRTMWD03	810	1240	1198	1238	1165	1224	1172	1363	1189	1183	1178	141
HGRK-PRTMWD11	810	1270	1235	1166	1071	1130	1179	1260	1132	1116	1137	132
Average for Deep Wells	**812**	**1259**	**1221**	**1203**	**1120**	**1174**	**1154**	**1308**	**1147**	**1139**	**1154**	**134**
Standard Deviation	**3**	**16**	**20**	**36**	**47**	**47**	**37**	**52**	**37**	**38**	**22**	
HGRK-PRTMWI01	310	340	352	337	330	333	351	356	371	330	341	17
HGRK-PRTMWI03	325	364	364	348	340	342	356	343	365	335	348	14
HGRK-PRTMWI11	305	369	382	353	347	347	361	355	374	335	353	22
Average for Intermediate Wells	**313**	**358**	**366**	**346**	**339**	**341**	**356**	**351**	**370**	**333**	**347**	**17**
Standard Deviation	**10**	**16**	**15**	**8**	**9**	**7**	**5**	**7**	**5**	**3**	**6**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	747	1190	1282	1180	1083	1118	1453	1135	1115	1095	1140	177
HGRK-PRTMWD05	810	1366	1378	1326	1205	1249	1252	1269	1232	1224	1231	160
HGRK-PRTMWD12	810	1247	1251	1174	1043	1083	1058	1132	1121	1069	1099	125
Average for Deep Wells	**789**	**1268**	**1304**	**1227**	**1110**	**1150**	**1254**	**1179**	**1156**	**1129**	**1157**	**144**
Standard Deviation	**36**	**90**	**66**	**86**	**84**	**88**	**198**	**78**	**66**	**83**	**68**	
HGRK-PRTMWI02	130	108	94	113	111	106	114	118	130	122	115	11
HGRK-PRTMWI05	135	130	119	101	103	101	102	108	122	123	114	13
HGRK-PRTMWI12	130	146	143	122	131	138	140	137	137	128	135	7
Average for Intermediate Wells	**132**	**128**	**119**	**112**	**115**	**115**	**119**	**121**	**130**	**124**	**121**	**7**
Standard Deviation	**3**	**19**	**25**	**11**	**14**	**20**	**19**	**15**	**8**	**3**	**12**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	730	1085	1145	1049	1002	1102	1168	1179	1010	1005	1048	130
HGRK-PRTMWI07	100	95	80	96	115	123	119	120	130	114	109	16
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	810	1166	1180	880	1115	1090	1134	1078	1028	1044	1053	121
HGRK-PRTMWI09	120	118	111	128	131	134	138	137	139	125	128	9
Average - all wells for each month	**494**	**719**	**722**	**676**	**651**	**674**	**701**	**712**	**670**	**654**	**667**	**485**
Standard Deviation of individual results from monthly average	**317**	**537**	**543**	**507**	**474**	**495**	**520**	**530**	**474**	**476**	**66**	

TABLE 4-10
ELECTRICAL CONDUCTIVITY SUMMARY

Well No.	ELECTRICAL CONDUCTIVITY (umhos/cm) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	35827	35857	35887	35917	35947	35977	36009	36039	36069	36101		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	815	1230	1245	1147	1062	1118	1079	1248	1110	1022	1108	130
HGRK-PRTMWD15	820	1292	1302	1204	1141	1031	1202	1385	1214	1135	1173	159
HGRK-PRTMWD19	800	1116	1146	1040	976	882	1045	1234	1095	1029	1036	127
Average for Deep Wells	**812**	**1213**	**1231**	**1130**	**1060**	**1010**	**1109**	**1289**	**1140**	**1062**	**1106**	**134**
Standard Deviation	**10**	**89**	**79**	**83**	**83**	**119**	**83**	**83**	**65**	**63**	**68**	
HGRK-PRTMWI13	405	474	466	422	413	410	411	397	405	351	415	35
HGRK-PRTMWI15	399	467	502	455	447	433	436	434	437	392	440	32
HGRK-PRTMWI19	375	414	431	391	389	389	398	400	411	386	398	16
Average for Intermediate Wells	**393**	**452**	**466**	**423**	**416**	**411**	**415**	**410**	**418**	**376**	**418**	**26**
Standard Deviation	**16**	**33**	**36**	**32**	**29**	**22**	**19**	**21**	**17**	**22**	**21**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	800	1357	1289	1318	1204	1234	1222	1425	1255	1251	1236	167
HGRK-PRTMWD16	820	1457	1375	1407	1366	1020	1549	1846	1639	1694	1417	307
HGRK-PRTMWD20	815	1316	1277	1254	1151	1187	1151	1366	1239	1237	1199	151
Average for Deep Wells	**812**	**1377**	**1314**	**1326**	**1240**	**1147**	**1307**	**1546**	**1378**	**1394**	**1284**	**196**
Standard Deviation	**10**	**73**	**53**	**77**	**112**	**112**	**212**	**262**	**226**	**260**	**117**	
HGRK-PRTMWI14	280	249	222	192	190	193	185	178	175	148	201	39
HGRK-PRTMWI16	575	398	288	215	246	238	210	207	314	295	299	114
HGRK-PRTMWI20	570	710	801	890	910	935	776	709	784	670	776	115
Average for Intermediate Wells	**475**	**452**	**437**	**432**	**449**	**455**	**390**	**365**	**424**	**371**	**425**	**38**
Standard Deviation	**169**	**235**	**317**	**397**	**401**	**416**	**334**	**299**	**319**	**269**	**307**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	812	1435	1495	1356	1262	1358	1450	1481	1454	1555	1366	212
HGRK-PRTMWI17	750	714	624	598	409	334	331	334	379	278	475	177
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	790	1223	1306	1159	1239	1326	1472	1464	1422	1416	1282	203
HGRK-PRTMWI18	370	529	379	374	391	335	314	NC	313	243	361	78
Average - all wells for each month	**637**	**899**	**884**	**839**	**800**	**776**	**827**	**941**	**853**	**819**	**824**	**440**
Standard Deviation of individual results from monthly average	**206**	**438**	**457**	**445**	**423**	**426**	**493**	**571**	**497**	**527**	**83**	

TABLE 4-11
TURBIDITY SUMMARY

Well No.	Turbidity (N.T.U.) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	2.4	3.0	2.0	2.0	1.0	1.0	2.0	1.0	0.0	1.0	1.5	0.9
HGRK-PRTMWD03	1.5	0.0	1.0	1.0	0.0	0.0	0.7	1.0	0.0	1.0	0.6	0.6
HGRK-PRTMWD11	2.1	2.0	1.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.7
Average for Deep Wells	**2.0**	**1.7**	**1.3**	**1.3**	**0.7**	**0.3**	**1.2**	**1.0**	**0.0**	**1.0**	**1.1**	**0.6**
Standard Deviation	**0.5**	**1.5**	**0.6**	**0.6**	**0.6**	**0.6**	**0.7**	**0.0**	**0.0**	**0.0**	**0.5**	
HGRK-PRTMWI01	1.1	0.0	1.0	1.0	0.0	0.0	0.6	0.0	0.0	0.0	0.4	0.5
HGRK-PRTMWI03	0.7	0.0	1.0	1.0	0.0	1.0	0.6	0.0	0.0	0.0	0.4	0.5
HGRK-PRTMWI11	0.1	0.0	1.0	1.0	0.0	0.0	0.5	0.0	0.0	0.0	0.3	0.4
Average for Intermediate Wells	**0.6**	**0.0**	**1.0**	**1.0**	**0.0**	**0.3**	**0.5**	**0.0**	**0.0**	**0.0**	**0.4**	**0.4**
Standard Deviation	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.6**	**0.1**	**0.0**	**0.0**	**0.0**	**0.1**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	1.8	1.0	2.0	2.0	1.0	1.0	0.9	1.0	0.0	1.0	1.2	0.6
HGRK-PRTMWD05	1.6	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	0.9	0.5
HGRK-PRTMWD12	1.7	0.0	1.0	1.0	0.0	1.0	1.0	1.0	0.0	1.0	0.8	0.6
Average for Deep Wells	**1.7**	**0.3**	**1.3**	**1.3**	**0.7**	**1.0**	**1.0**	**1.0**	**0.0**	**1.0**	**0.9**	**0.5**
Standard Deviation	**0.1**	**0.6**	**0.6**	**0.6**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	
HGRK-PRTMWI02	62.3	1.0	2.0	2.0	1.0	1.0	2.1	1.0	0.8	1.0	7.4	19.3
HGRK-PRTMWI05	3.8	1.0	1.0	1.0	1.0	1.0	1.6	1.0	1.3	0.0	1.3	1.0
HGRK-PRTMWI12	1.1	2.0	2.0	2.0	1.0	1.0	0.7	1.0	1.0	0.0	1.2	0.6
Average for Intermediate Wells	**22.4**	**1.3**	**1.7**	**1.7**	**1.0**	**1.0**	**1.5**	**1.0**	**1.0**	**0.3**	**3.3**	**6.7**
Standard Deviation	**34.6**	**0.6**	**0.6**	**0.6**	**0.0**	**0.0**	**0.7**	**0.0**	**0.3**	**0.6**	**3.6**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	790	9.0	7.0	7.0	4.0	2.0	7.4	5.0	4.0	7.0	84.2	248.0
HGRK-PRTMWI07	6.2	1.0	1.0	1.0	3.0	3.0	2.4	1.0	0.5	0.0	1.9	1.8
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	5.3	1.0	1.0	1.0	1.0	2.0	0.9	1.0	1.0	1.0	1.5	1.4
HGRK-PRTMWI09	6.9	6.0	9.0	9.0	6.0	5.0	4.3	4.0	3.9	2.0	5.6	2.3
Average - all wells for each month	**55.5**	**1.7**	**2.1**	**2.1**	**1.3**	**1.3**	**1.7**	**1.3**	**0.8**	**1.1**	**6.9**	**20.7**
Standard Deviation of individual results from monthly average	**196.4**	**2.5**	**2.4**	**2.4**	**1.7**	**1.3**	**1.8**	**1.3**	**1.3**	**1.7**	**17.1**	

790	The turbidity reading for HGRK-PRTMWD07 in February is believed to be accurate. Althought subsequent clearing occurred, the development records show that during the first sampling event the purge water had color. Readings and descriptions for each purge volume are as follows: 1) 36.2 N.T.U, no color; 2) 3,500 N.T.U., medium grey; 3) 790 N.T.U. light grey.
NC =	Not Collected

TABLE 4-11
TURBIDITY SUMMARY

Well No.	Turbidity (N.T.U.) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	0.9	0.0	2.0	2.0	0.0	0.0	0.9	1.0	0.0	0.0	0.7	0.8
HGRK-PRTMWD15	1.4	1.0	1.0	1.0	1.0	0.0	0.9	1.0	0.0	1.0	0.8	0.5
HGRK-PRTMWD19	3.5	0.0	1.0	1.0	1.0	0.0	0.8	NC	0.0	0.0	0.8	1.1
Average for Deep Wells	**1.9**	**0.3**	**1.3**	**1.3**	**0.7**	**0.0**	**0.9**	**1.0**	**0.0**	**0.3**	**0.8**	**0.6**
Standard Deviation	**1.4**	**0.6**	**0.6**	**0.6**	**0.6**	**0.0**	**0.1**	**0.0**	**0.0**	**0.6**	**0.1**	
HGRK-PRTMWI13	3.7	0.0	1.0	1.0	0.0	1.0	0.5	1.0	0.0	0.0	0.8	1.1
HGRK-PRTMWI15	1.1	0.0	1.0	1.0	0.0	0.0	0.6	1.0	0.0	0.0	0.5	0.5
HGRK-PRTMWI19	2.8	3.0	2.0	2.0	2.0	1.0	1.1	1.0	0.0	0.0	1.5	1.0
Average for Intermediate Wells	**2.5**	**1.0**	**1.3**	**1.3**	**0.7**	**0.7**	**0.7**	**1.0**	**0.0**	**0.0**	**0.9**	**0.7**
Standard Deviation	**1.3**	**1.7**	**0.6**	**0.6**	**1.2**	**0.6**	**0.3**	**0.0**	**0.0**	**0.0**	**0.5**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	1.7	0.0	0.0	0.0	0.0	1.0	0.7	1.0	0.0	0.0	0.4	0.6
HGRK-PRTMWD16	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	0.6	0.5
HGRK-PRTMWD20	1.8	1.0	1.0	1.0	0.0	0.0	0.6	1.0	0.0	0.0	0.6	0.6
Average for Deep Wells	**1.5**	**0.3**	**0.3**	**0.3**	**0.0**	**0.7**	**0.7**	**1.0**	**0.3**	**0.3**	**0.6**	**0.4**
Standard Deviation	**0.4**	**0.6**	**0.6**	**0.6**	**0.0**	**0.6**	**0.2**	**0.0**	**0.6**	**0.6**	**0.1**	
HGRK-PRTMWI14	0.6	1.0	2.0	2.0	2.0	3.0	2.8	2.0	2.0	2.0	1.9	0.7
HGRK-PRTMWI16	1.4	1.0	2.0	2.0	2.0	1.0	2.5	3.0	5.0	5.0	2.5	1.5
HGRK-PRTMWI20	0.8	2.0	4.0	4.0	5.0	3.0	3.6	2.0	1.0	2.0	2.7	1.4
Average for Intermediate Wells	**0.9**	**1.3**	**2.7**	**2.7**	**3.0**	**2.3**	**3.0**	**2.3**	**2.7**	**3.0**	**2.4**	**0.7**
Standard Deviation	**0.4**	**0.6**	**1.2**	**1.2**	**1.7**	**1.2**	**0.6**	**0.6**	**2.1**	**1.7**	**0.4**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	1.4	1.0	1.0	1.0	1.0	1.0	0.7	1.0	0.0	1.0	0.9	0.4
HGRK-PRTMWI17	1.5	2.0	3.0	3.0	2.0	2.0	2.0	2.0	4.0	1.0	2.3	0.9
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	3.7	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.1	1.0
HGRK-PRTMWI18	4.8	3.0	2.0	2.0	2.0	2.0	1.8	1.0	1.8	1.0	2.1	1.1
Average - all wells for each month	**2.0**	**0.9**	**1.5**	**1.5**	**1.2**	**1.1**	**1.3**	**1.3**	**0.9**	**0.9**	**1.3**	**0.8**
Standard Deviation of individual results from monthly average	**1.3**	**1.1**	**1.0**	**1.0**	**1.3**	**1.0**	**0.9**	**0.6**	**1.6**	**1.3**	**0.3**	

790	The turbidity reading for HGRK-PRTMWD07 in February is believed to be accurate. Althought subsequent clearing occurred, the development records show that during the first sampling event the purge water had color. Readings and descriptions for each purge volume are as follows: 1) 36.2 N.T.U, no color; 2) 3,500 N.T.U., medium grey; 3) 790 N.T.U. light grey.
NC =	Not Collected

TABLE 4-12
TOTAL IRON CONCENTRATION SUMMARY

Well No.	TOTAL IRON CONCENTRATION SUMMARY										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	0.6	0.7	0.6	0.7	0.9	0.9	1.2	1.0	0.8	0.2	0.7	0.3
HGRK-PRTMWD03	0.0	0.0	0.0	0.0	0.4	0.2	0.2	NC	0.5	0.5	0.2	0.2
HGRK-PRTMWD11	0.4	0.5	0.4	0.5	0.5	0.4	0.2	0.5	0.2	0.4	0.4	0.1
Average for Deep Wells	**0.3**	**0.4**	**0.3**	**0.4**	**0.6**	**0.5**	**0.5**	**0.8**	**0.5**	**0.4**	**0.4**	**0.1**
Standard Deviation	**0.3**	**0.4**	**0.3**	**0.4**	**0.3**	**0.4**	**0.6**	**0.4**	**0.3**	**0.2**	**0.3**	
HGRK-PRTMWI01	0.4	0.4	0.6	0.6	0.6	0.5	0.6	0.5	0.5	0.6	0.5	0.1
HGRK-PRTMWI03	0.4	0.5	0.7	0.5	0.4	0.5	0.7	0.5	0.5	0.5	0.5	0.1
HGRK-PRTMWI11	0.6	0.7	0.7	0.7	0.7	0.5	0.7	0.6	0.7	0.7	0.7	0.1
Average for Intermediate Wells	**0.5**	**0.5**	**0.7**	**0.6**	**0.6**	**0.5**	**0.7**	**0.5**	**0.6**	**0.6**	**0.6**	**0.1**
Standard Deviation	**0.1**	**0.2**	**0.1**	**0.1**	**0.2**	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.2	0.2	0.0	0.1	0.1
HGRK-PRTMWD05	0.5	0.5	0.5	0.6	0.8	0.6	0.6	0.7	0.6	0.6	0.6	0.1
HGRK-PRTMWD12	0.2	0.0	NC	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1
Average for Deep Wells	**0.2**	**0.2**	**0.3**	**0.2**	**0.3**	**0.2**	**0.3**	**0.4**	**0.3**	**0.2**	**0.2**	**0.1**
Standard Deviation	**0.3**	**0.3**	**0.4**	**0.3**	**0.4**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	
HGRK-PRTMWI02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HGRK-PRTMWI05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HGRK-PRTMWI12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average for Intermediate Wells	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Standard Deviation	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	1.4	1.5	1.8	1.9	2.0	0.2	2.3	2.6	2.5	2.4	1.9	0.7
HGRK-PRTMWI07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	0.5	0.4	0.0	0.0	0.0	0.0	0.0	NC	0.0	0.0	0.1	0.2
HGRK-PRTMWI09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1
Average - all wells for each month	**0.3**	**0.3**	**0.4**	**0.3**	**0.4**	**0.2**	**0.4**	**0.5**	**0.4**	**0.4**	**0.4**	**0.5**
Standard Deviation of individual results from monthly average	**0.4**	**0.4**	**0.5**	**0.5**	**0.5**	**0.3**	**0.6**	**0.7**	**0.6**	**0.6**	**0.1**	

NC= NOT COLLECTED

TABLE 4-12
TOTAL IRON CONCENTRATION SUMMARY

Well No.	TOTAL IRON CONCENTRATION SUMMARY										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.0
HGRK-PRTMWD15	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
HGRK-PRTMWD19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.1	0.1
Average for Deep Wells	**0.3**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**	**0.0**
Standard Deviation	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	
HGRK-PRTMWI13	0.6	0.6	0.4	0.5	0.5	0.5	0.6	0.5	0.3	0.5	0.5	0.1
HGRK-PRTMWI15	0.2	0.5	0.4	0.6	0.7	0.5	0.8	0.7	0.5	0.4	0.5	0.2
HGRK-PRTMWI19	0.0	0.4	0.2	0.5	0.4	0.4	0.5	0.4	0.3	0.3	0.3	0.2
Average for Intermediate Wells	**0.3**	**0.5**	**0.3**	**0.5**	**0.5**	**0.5**	**0.6**	**0.5**	**0.4**	**0.4**	**0.5**	**0.1**
Standard Deviation	**0.3**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HGRK-PRTMWD16	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	0.6	0.9	0.3	0.3
HGRK-PRTMWD20	0.7	0.6	0.5	0.4	0.5	0.4	0.4	0.2	0.3	0.5	0.5	0.1
Average for Deep Wells	**0.2**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**	**0.3**	**0.2**	**0.3**	**0.5**	**0.2**	**0.1**
Standard Deviation	**0.4**	**0.3**	**0.3**	**0.2**	**0.3**	**0.2**	**0.3**	**0.2**	**0.3**	**0.5**	**0.2**	
HGRK-PRTMWI14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HGRK-PRTMWI16	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
HGRK-PRTMWI20	0.6	0.5	1.0	2.0	2.6	3.1	2.5	2.0	2.1	2.0	1.8	1.0
Average for Intermediate Wells	**0.3**	**0.2**	**0.3**	**0.7**	**0.9**	**1.0**	**0.8**	**0.0**	**0.7**	**0.0**	**0.6**	**0.4**
Standard Deviation	**0.3**	**0.3**	**0.6**	**1.2**	**1.5**	**1.8**	**1.4**	**0.0**	**1.2**	**0.0**	**1.0**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.2	0.1	0.1
HGRK-PRTMWI17	0.0	0.5	0.6	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.2	0.3
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1
HGRK-PRTMWI18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average - all wells for each month	**0.2**	**0.2**	**0.2**	**0.3**	**0.4**	**0.3**	**0.4**	**0.2**	**0.3**	**0.2**	**0.3**	**0.4**
Standard Deviation of individual results from monthly average	**0.3**	**0.3**	**0.3**	**0.5**	**0.6**	**0.8**	**0.6**	**0.2**	**0.5**	**0.3**	**0.1**	

NC= NOT COLLECTED

TABLE 4-13
Fe +2 CONCENTRATION SUMMARY

Well No.	FE +2 (mg/L) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	0.7	0.7	0.3	0.6	0.6	0.6	0.4	0.9	0.6	0.9	0.6	0.2
HGRK-PRTMWD03	0.0	0.0	0.0	0.0	0.4	0.0	0.2	NC	0.2	0.2	0.1	0.1
HGRK-PRTMWD11	0.4	0.2	0.0	0.4	0.0	0.2	0.2	0.4	0.2	0.2	0.2	0.1
Average for Deep Wells	**0.4**	**0.3**	**0.1**	**0.3**	**0.3**	**0.3**	**0.3**	**0.7**	**0.3**	**0.4**	**0.3**	**0.1**
Standard Deviation	**0.4**	**0.4**	**0.2**	**0.3**	**0.3**	**0.3**	**0.1**	**0.4**	**0.2**	**0.4**	**0.3**	
HGRK-PRTMWI01	0.4	0.2	0.4	0.7	0.4	0.4	0.6	0.0	0.4	0.4	0.4	0.2
HGRK-PRTMWI03	0.4	0.2	0.6	0.2	0.4	0.5	0.6	0.4	0.2	0.3	0.4	0.2
HGRK-PRTMWI11	0.5	0.3	0.7	0.6	0.4	0.6	0.5	0.4	0.9	0.6	0.6	0.2
Average for Intermediate Wells	**0.4**	**0.2**	**0.6**	**0.5**	**0.4**	**0.5**	**0.6**	**0.3**	**0.5**	**0.4**	**0.4**	**0.1**
Standard Deviation	**0.1**	**0.1**	**0.2**	**0.3**	**0.0**	**0.1**	**0.1**	**0.2**	**0.4**	**0.2**	**0.1**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	0.0	0.0	0.0	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1
HGRK-PRTMWD05	0.4	0.3	0.6	0.4	0.6	0.5	0.6	0.0	0.7	0.6	0.5	0.2
HGRK-PRTMWD12	0.2	0.0	NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Average for Deep Wells	**0.2**	**0.1**	**0.3**	**0.3**	**0.3**	**0.2**	**0.3**	**0.1**	**0.3**	**0.3**	**0.2**	**0.1**
Standard Deviation	**0.2**	**0.2**	**0.4**	**0.2**	**0.3**	**0.3**	**0.3**	**0.1**	**0.4**	**0.3**	**0.2**	
HGRK-PRTMWI02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HGRK-PRTMWI05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HGRK-PRTMWI12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average for Intermediate Wells	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Standard Deviation	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	0.6	0.6	0.5	0.2	0.0	0.6	1.0	1.0	0.2	0.5	0.5	0.3
HGRK-PRTMWI07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	0.5	0.5	0.2	0.0	0.0	0.0	0.0	NC	0.0	0.0	0.1	0.2
HGRK-PRTMWI09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average - all wells for each month	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**
Standard Deviation of individual results from monthly average	**0.3**	**0.2**	**0.3**	**0.3**	**0.2**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.0**	

NC= NOT COLLECTED

TABLE 4-13
Fe +2 CONCENTRATION SUMMARY

Well No.	FE +2 (mg/L) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	0.4	0.2	0.2	0.4	0.4	0.2	0.2	0.4	0.3	0.2	0.3	0.1
HGRK-PRTMWD15	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
HGRK-PRTMWD19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.1
Average for Deep Wells	**0.3**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**
Standard Deviation	**0.2**	**0.1**	**0.1**	**0.2**	**0.2**	**0.1**	**0.1**	**0.2**	**0.2**	**0.1**	**0.1**	
HGRK-PRTMWI13	0.4	0.0	0.4	0.1	0.4	0.4	0.7	0.5	0.2	0.4	0.4	0.2
HGRK-PRTMWI15	0.2	0.0	0.6	0.3	0.5	0.4	0.7	0.4	0.7	0.6	0.4	0.2
HGRK-PRTMWI19	0.2	0.0	0.0	0.0	0.0	0.2	0.2	0.3	0.2	0.2	0.1	0.1
Average for Intermediate Wells	**0.3**	**0.0**	**0.3**	**0.1**	**0.3**	**0.3**	**0.5**	**0.4**	**0.4**	**0.4**	**0.3**	**0.1**
Standard Deviation	**0.1**	**0.0**	**0.3**	**0.2**	**0.3**	**0.1**	**0.3**	**0.1**	**0.3**	**0.2**	**0.2**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HGRK-PRTMWD16	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.6	0.6	0.2	0.3
HGRK-PRTMWD20	0.6	0.5	0.2	0.4	0.6	0.2	0.4	0.2	0.2	0.4	0.4	0.2
Average for Deep Wells	**0.2**	**0.2**	**0.1**	**0.1**	**0.2**	**0.1**	**0.3**	**0.2**	**0.3**	**0.3**	**0.2**	**0.1**
Standard Deviation	**0.3**	**0.3**	**0.1**	**0.2**	**0.3**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**	**0.2**	
HGRK-PRTMWI14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HGRK-PRTMWI16	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
HGRK-PRTMWI20	0.2	0.2	1.0	1.1	2.0	2.1	2.1	0.5	1.9	1.3	1.2	0.8
Average for Intermediate Wells	**0.2**	**0.1**	**0.3**	**0.4**	**0.7**	**0.7**	**0.7**	**0.2**	**0.6**	**0.4**	**0.4**	**0.2**
Standard Deviation	**0.2**	**0.1**	**0.6**	**0.6**	**1.2**	**1.2**	**1.2**	**0.3**	**1.1**	**0.8**	**0.7**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.1
HGRK-PRTMWI17	0.0	0.5	0.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1
HGRK-PRTMWI18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average - all wells for each month	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.3**	**0.2**	**0.3**	**0.3**	**0.2**	**0.3**
Standard Deviation of individual results from monthly average	**0.2**	**0.2**	**0.3**	**0.3**	**0.5**	**0.5**	**0.5**	**0.2**	**0.5**	**0.3**	**0.1**	

NC= NOT COLLECTED

TABLE 4-14
HARDNESS (mg/L as $CaCO_3$) CONCENTRATION SUMMARY

Well No.	HARDNESS (mg/L as $CaCO_3$) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	480	480	500	479	496	479	496	479	462	428	478	21
HGRK-PRTMWD03	420	440	460	479	462	496	479	NC	496	496	470	27
HGRK-PRTMWD11	460	480	460	445	496	462	479	445	462	479	467	16
Average for Deep Wells	**453**	**467**	**473**	**468**	**485**	**479**	**485**	**462**	**473**	**468**	**471**	**10**
Standard Deviation	**31**	**23**	**23**	**20**	**20**	**17**	**10**	**24**	**20**	**35**	**6**	
HGRK-PRTMWI01	188	188	205	171	171	100	171	154	188	171	171	29
HGRK-PRTMWI03	205	205	188	171	171	171	171	171	188	171	181	14
HGRK-PRTMWI11	205	188	205	188	171	188	171	171	188	188	186	13
Average for Intermediate Wells	**200**	**194**	**199**	**177**	**171**	**153**	**171**	**165**	**188**	**177**	**179**	**15**
Standard Deviation	**10**	**10**	**10**	**10**	**0**	**47**	**0**	**10**	**0**	**10**	**8**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	400	420	460	428	445	410	427	427	428	410	426	17
HGRK-PRTMWD05	460	480	520	496	530	462	496	462	462	428	480	31
HGRK-PRTMWD12	440	420	NC	342	359	342	393	342	359	325	369	40
Average for Deep Wells	**433**	**440**	**490**	**422**	**445**	**405**	**439**	**410**	**416**	**388**	**425**	**28**
Standard Deviation	**31**	**35**	**42**	**77**	**86**	**60**	**52**	**62**	**52**	**55**	**55**	
HGRK-PRTMWI02	34	24	28	25	16	17	21	21	30	37	25	7
HGRK-PRTMWI05	32	29	24	24	24	20	26	21	21	31	25	4
HGRK-PRTMWI12	27	20	17	17	19	21	20	22	21	24	21	3
Average for Intermediate Wells	**31**	**24**	**23**	**22**	**20**	**19**	**22**	**21**	**24**	**31**	**24**	**4**
Standard Deviation	**4**	**5**	**6**	**4**	**4**	**2**	**3**	**1**	**5**	**7**	**3**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	280	320	320	325	291	393	359	393	342	342	337	38
HGRK-PRTMWI07	19	16	21	16	15	14	16	20	33	34	20	7
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	480	440	380	410	428	410	427	NC	359	376	412	37
HGRK-PRTMWI09	23	16	16	137	15	14	16	15	17	16	29	38
Average - all wells for each month	**260**	**260**	**254**	**260**	**257**	**250**	**261**	**225**	**254**	**247**	**256**	**191**
Standard Deviation of individual results from monthly average	**189**	**194**	**200**	**185**	**203**	**198**	**200**	**191**	**187**	**181**	**11**	

NC= NOT COLLECTED

TABLE 4-14
HARDNESS (mg/L as CaCO3) CONCENTRATION SUMMARY

Well No.	HARDNESS (mg/L as CaCO3) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	480	520	NC	462	462	462	462	427	428	445	461	28
HGRK-PRTMWD15	480	480	480	479	479	513	380	479	513	462	475	37
HGRK-PRTMWD19	340	420	400	376	410	393	427	410	410	393	398	25
Average for Deep Wells	**433**	**473**	**440**	**439**	**450**	**456**	**423**	**439**	**450**	**433**	**444**	**14**
Standard Deviation	**81**	**50**	**57**	**55**	**36**	**60**	**41**	**36**	**55**	**36**	**41**	
HGRK-PRTMWI13	188	188	205	188	188	171	188	188	171	171	185	11
HGRK-PRTMWI15	205	205	188	188	188	205	205	171	171	171	190	15
HGRK-PRTMWI19	170	171	154	137	154	154	154	154	154	137	154	11
Average for Intermediate Wells	**188**	**188**	**182**	**171**	**177**	**177**	**182**	**171**	**165**	**160**	**176**	**9**
Standard Deviation	**18**	**17**	**26**	**29**	**20**	**26**	**26**	**17**	**10**	**20**	**19**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	440	480	480	496	513	513	513	530	564	496	503	33
HGRK-PRTMWD16	460	520	480	564	599	564	684	752	736	736	610	110
HGRK-PRTMWD20	520	520	480	496	496	513	462	496	513	496	499	18
Average for Deep Wells	**473**	**507**	**480**	**519**	**536**	**530**	**553**	**593**	**604**	**576**	**537**	**45**
Standard Deviation	**42**	**23**	**0**	**39**	**55**	**29**	**116**	**139**	**117**	**139**	**63**	
HGRK-PRTMWI14	137	51	51	41	43	37	39	33	29	28	49	32
HGRK-PRTMWI16	291	120	68	34	47	41	41	30	43	39	75	80
HGRK-PRTMWI20	291	257	291	342	359	400	363	256	325	239	312	54
Average for Intermediate Wells	**239**	**143**	**137**	**139**	**150**	**159**	**148**	**106**	**132**	**102**	**146**	**38**
Standard Deviation	**89**	**105**	**134**	**176**	**181**	**208**	**186**	**130**	**167**	**119**	**145**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	460	540	540	547	530	513	581	633	667	701	571	74
HGRK-PRTMWI17	513	274	274	239	188	103	103	85	86	68	193	138
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	380	420	440	445	513	564	633	701	667	581	534	112
HGRK-PRTMWI18	120	160	137	17	154	102	86	58	86	38	96	48
Average - all wells for each month	**342**	**333**	**311**	**316**	**333**	**328**	**333**	**338**	**348**	**325**	**331**	**195**
Standard Deviation of individual results from monthly average	**143**	**170**	**169**	**194**	**189**	**202**	**217**	**246**	**245**	**242**	**11**	

NC= NOT COLLECTED

TABLE 4-15
OXIDATION-REDUCTION POTENTIAL SUMMARY

Well No.	OXIDATION-REDUCTION POTENTIAL SUMMARY										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	-109	-114	-113	-130	-106	-120	-120	-163	-123	-143	-124	17
HGRK-PRTMWD03	-67	-102	-109	-91	-105	-84	-104	NC	-104	-118	-98	15
HGRK-PRTMWD11	-120	-130	-98	-79	-89	-106	-113	-125	-123	-113	-110	17
Average for Deep Wells	**-99**	**-115**	**-107**	**-100**	**-100**	**-103**	**-112**	**-144**	**-117**	**-125**	**-111**	**14**
Standard Deviation	**28**	**14**	**8**	**27**	**10**	**18**	**8**	**27**	**11**	**16**	**13**	
HGRK-PRTMWI01	14	-83	-109	-112	-69	-110	-86	-89	-112	-69	-83	38
HGRK-PRTMWI03	-42	-85	-108	-101	-92	-106	-96	-98	-76	-53	-86	22
HGRK-PRTMWI11	-42	-109	-125	-108	-94	-109	-86	-102	-135	-108	-102	25
Average for Intermediate Wells	**-23**	**-92**	**-114**	**-107**	**-85**	**-108**	**-89**	**-96**	**-108**	**-77**	**-90**	**26**
Standard Deviation	**32**	**14**	**10**	**6**	**14**	**2**	**6**	**7**	**30**	**28**	**10**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	-139	-170	-154	-146	-165	-164	-162	-195	-125	-170	-159	19
HGRK-PRTMWD05	-150	-156	-149	-128	-130	-114	-140	-84	-153	-150	-135	22
HGRK-PRTMWD12	-216	-225	NC	-185	-192	-190	-146	-197	-200	-188	-193	22
Average for Deep Wells	**-168**	**-184**	**-152**	**-153**	**-162**	**-156**	**-149**	**-159**	**-159**	**-169**	**-163**	**10**
Standard Deviation	**42**	**36**	**4**	**29**	**31**	**39**	**11**	**65**	**38**	**19**	**29**	
HGRK-PRTMWI02	-193	-191	-170	-145	-148	-145	-142	-116	-135	-157	-154	24
HGRK-PRTMWI05	-165	-174	-179	-157	-151	-144	-132	-135	-166	-133	-154	17
HGRK-PRTMWI12	-157	-175	-182	-139	-144	-92	-93	-118	-101	-75	-128	37
Average for Intermediate Wells	**-172**	**-180**	**-177**	**-147**	**-148**	**-127**	**-122**	**-123**	**-134**	**-122**	**-145**	**23**
Standard Deviation	**19**	**10**	**6**	**9**	**4**	**30**	**26**	**10**	**33**	**42**	**15**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	-240	-209	-166	-105	-104	-138	-196	-180	-72	-160	-157	53
HGRK-PRTMWI07	-158	-157	-181	-156	-142	-115	-106	-104	-122	-52	-129	37
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	-200	-139	-170	-116	-146	-136	-163	NC	-138	-145	-150	24
HGRK-PRTMWI09	-218	-170	-130	-172	-146	-145	-109	-99	-130	-103	-142	37
Average - all wells for each month	**-138**	**-149**	**-143**	**-129**	**-126**	**-126**	**-125**	**-129**	**-126**	**-121**	**-131**	**30**
Standard Deviation of individual results from monthly average	**73**	**43**	**31**	**30**	**33**	**28**	**32**	**39**	**31**	**42**	**9**	

NC= NOT COLLECTED

167 Measurement believed to be in error.

TABLE 4-15
OXIDATION-REDUCTION POTENTIAL SUMMARY

Well No.	OXIDATION-REDUCTION POTENTIAL SUMMARY										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	-146	-138	NC	-121	-110	-103	-101	-113	-121	-73	-114	21
HGRK-PRTMWD15	-174	-176	-171	-145	-145	-142	-154	-151	-188	-178	-162	17
HGRK-PRTMWD19	-152	-158	-116	-113	-93	-52	-147	-166	-145	-152	-129	36
Average for Deep Wells	**-157**	**-157**	**-144**	**-126**	**-116**	**-99**	**-134**	**-143**	**-151**	**-134**	**-135**	**19**
Standard Deviation	**15**	**19**	**39**	**17**	**27**	**45**	**29**	**27**	**34**	**55**	**25**	
HGRK-PRTMWI13	-109	-70	-122	-89	-116	-137	-151	-146	-80	-120	-114	27
HGRK-PRTMWI15	-104	-131	-120	-103	-116	-133	-127	-98	-137	-136	-121	15
HGRK-PRTMWI19	-150	-164	-147	-129	-129	-108	-134	-155	-101	-147	-136	20
Average for Intermediate Wells	**-121**	**-122**	**-130**	**-107**	**-120**	**-126**	**-137**	**-133**	**-106**	**-134**	**-124**	**11**
Standard Deviation	**25**	**48**	**15**	**20**	**8**	**16**	**12**	**31**	**29**	**14**	**12**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	-204	-205	-222	-184	-196	-186	-198	-228	-221	-197	-204	15
HGRK-PRTMWD16	-215	-213	-214	-205	-187	-166	-109	-193	-141	-156	-180	36
HGRK-PRTMWD20	-148	-145	-145	-129	-159	-152	-158	-131	-148	167	-115	100
Average for Deep Wells	**-189**	**-188**	**-194**	**-173**	**-181**	**-168**	**-155**	**-184**	**-170**	**-62**	**-166**	**38**
Standard Deviation	**36**	**37**	**42**	**39**	**19**	**17**	**45**	**49**	**44**	**199**	**46**	
HGRK-PRTMWI14	-98	-164	-186	-166	-146	-154	-175	-136	-147	-139	-151	25
HGRK-PRTMWI16	-109	-141	-197	-104	-148	-166	-172	-180	-178	-171	-157	31
HGRK-PRTMWI20	-78	126	-128	-99	-117	-116	-139	-111	-146	-138	-95	80
Average for Intermediate Wells	**-95**	**-60**	**-170**	**-123**	**-137**	**-145**	**-162**	**-142**	**-157**	**-149**	**-134**	**34**
Standard Deviation	**16**	**161**	**37**	**37**	**17**	**26**	**20**	**35**	**18**	**19**	**34**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	-197	-210	-189	-195	-205	-211	-210	-218	-145	-183	-196	21
HGRK-PRTMWI17	-137	-126	-114	-136	-109	-126	-146	-101	-157	-154	-131	19
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	-204	-207	-189	-186	-176	-167	-209	-202	-180	-174	-189	15
HGRK-PRTMWI18	-201	-170	-171	-153	-119	-156	-138	-200	-141	-118	-157	29
Average - all wells for each month	**-152**	**-143**	**-162**	**-141**	**-142**	**-142**	**-154**	**-158**	**-149**	**-129**	**-147**	**33**
Standard Deviation of individual results from monthly average	**44**	**81**	**37**	**37**	**34**	**37**	**32**	**42**	**33**	**85**	**10**	

NC= NOT COLLECTED

167 Measurement believed to be in error.

TABLE 4-16
SULFATE CONCENTRATION SUMMARY

Well No.	SULFATE (mg/L) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWD03	<50	<50	<50	<50	<50	<50	NC	NC	<50	<50	<50	NA
HGRK-PRTMWD11	100	80	<50	<50	<50	<50	NC	<50	<50	<50	<59	NA
Average for Deep Wells	**<67**	**<60**	**<50**	**<50**	**<50**	**<50**	**NA**	**<50**	**<50**	**<50**	**<53**	NA
Standard Deviation	**29**	**17**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	
HGRK-PRTMWI01	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWI03	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWI11	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
Average for Intermediate Wells	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**NA**	**<50**	**<50**	**<50**	**<50**	**NA**
Standard Deviation	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWD05	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWD12	90	<50	NC	<50	<50	<50	NC	<50	<50	<50	<55	NA
Average for Deep Wells	**<63**	**<50**	**<50**	**<50**	**<50**	**<50**	**NA**	**<50**	**<50**	**<50**	**<52**	NA
Standard Deviation	**23**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	
HGRK-PRTMWI02	<50	<50	<50	<50	<50	<50	NC	<50	<50	55	<51	NA
HGRK-PRTMWI05	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWI12	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
Average for Intermediate Wells	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**NA**	**<50**	**<50**	**<52**	**<50**	**NA**
Standard Deviation	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWI07	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	125	70	<50	<50	<50	<50	NC	NC	<50	<50	<62	NA
HGRK-PRTMWI09	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
Average - all wells for each month	**<105**	**<75**	**<50**	**<50**	**<50**	**<50**	**NC**	**<50**	**<50**	**<53**	**<52**	**NA**
Standard Deviation of individual results from monthly average	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

NC= NOT COLLECTED

TABLE 4-16
SULFATE CONCENTRATION SUMMARY

Well No.	SULFATE (mg/L) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	65	<50	NC	<50	<50	<50	NC	<50	<50	<50	<52	NA
HGRK-PRTMWD15	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWD19	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
Average for Deep Wells	**<55**	**<50**	**<50**	**<50**	**<50**	**<50**	**NA**	**<50**	**<50**	**<50**	**<51**	**NA**
Standard Deviation	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	
HGRK-PRTMWI13	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWI15	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWI19	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
Average for Intermediate Wells	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**NA**	**<50**	**<50**	**<50**	**<50**	**NA**
Standard Deviation	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	<50	65	65	60	<50	<50	NC	<50	<50	<50	<55	NA
HGRK-PRTMWD16	70	75	<50	<50	<50	<50	NC	<50	<50	<50	<56	NA
HGRK-PRTMWD20	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
Average for Deep Wells	**<57**	**<63**	**<55**	**<53**	**<50**	**<50**	**NA**	**<50**	**<50**	**<50**	**<54**	**NA**
Standard Deviation	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	
HGRK-PRTMWI14	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWI16	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
HGRK-PRTMWI20	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
Average for Intermediate Wells	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**NA**	**<50**	**<50**	**<50**	**<50**	**NA**
Standard Deviation	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	150	70	<50	<50	<50	<50	NC	<50	<50	<50	<65	NA
HGRK-PRTMWI17	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	175	125	80	60	<50	<50	NC	<50	<50	<50	<80	NA
HGRK-PRTMWI18	<50	<50	<50	<50	<50	<50	NC	<50	<50	<50	<50	NA
Average - all wells for each month	**<66**	**<58**	**<53**	**<51**	**<50**	**<50**	**--**	**<50**	**<50**	**<50**	**<53**	**NA**
Standard Deviation of individual results from monthly average	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	

NC= NOT COLLECTED

TABLE 4-17
DISSOLVED OXYGEN CONCENTRATION SUMMARY

Well No.	DISSOLVED OXYGEN (mg/L) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	0.4	0.2	0.4	0.4	NC	0.5	0.2	NC	0.2	0.3	0.3	0.1
HGRK-PRTMWD03	0.4	0.3	0.4	0.3	NC	0.5	0.2	NC	0.1	0.3	0.3	0.1
HGRK-PRTMWD11	0.4	0.2	0.3	NC	NC	0.4	0.2	NC	0.2	0.2	0.3	0.1
Average for Deep Wells	**0.4**	**0.2**	**0.4**	**0.4**	**NA**	**0.5**	**0.2**	**NA**	**0.2**	**0.3**	**0.3**	**0.1**
Standard Deviation	**0.0**	**0.1**	**0.1**	**0.1**	**NA**	**0.1**	**0.0**	**NA**	**0.1**	**0.1**	**0.0**	
HGRK-PRTMWI01	0.2	0.3	0.2	0.2	NC	NC	0.5	NC	0.4	0.3	0.3	0.1
HGRK-PRTMWI03	0.2	0.2	0.2	0.2	NC	NC	0.5	NC	0.3	0.4	0.3	0.1
HGRK-PRTMWI11	0.4	0.2	0.4	0.2	NC	NC	0.6	NC	0.2	0.4	0.3	0.2
Average for Intermediate Wells	**0.3**	**0.2**	**0.3**	**0.2**	**NA**	**NA**	**0.5**	**NA**	**0.3**	**0.4**	**0.3**	**0.1**
Standard Deviation	**0.1**	**0.1**	**0.1**	**0.0**	**NA**	**NA**	**0.1**	**NA**	**0.1**	**0.1**	**0.0**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	0.4	0.3	0.2	0.3	NC	NC	0.4	NC	0.6	0.2	0.3	0.1
HGRK-PRTMWD05	0.4	0.2	0.2	0.3	NC	NC	0.4	NC	0.3	0.2	0.3	0.1
HGRK-PRTMWD12	0.2	0.3	0.3	0.3	NC	NC	0.6	NC	0.2	0.2	0.3	0.1
Average for Deep Wells	**0.3**	**0.3**	**0.2**	**0.3**	**NA**	**NA**	**0.5**	**NA**	**0.4**	**0.2**	**0.3**	**0.1**
Standard Deviation	**0.1**	**0.1**	**0.1**	**0.0**	**NA**	**NA**	**0.1**	**NA**	**0.2**	**0.0**	**0.0**	
HGRK-PRTMWI02	0.4	0.4	0.5	0.4	NC	NC	0.5	NC	0.3	0.6	0.4	0.1
HGRK-PRTMWI05	0.8	0.2	0.4	0.2	NC	NC	0.4	NC	0.4	0.3	0.4	0.2
HGRK-PRTMWI12	0.4	0.3	0.4	0.6	NC	NC	0.6	NC	0.4	0.2	0.4	0.1
Average for Intermediate Wells	**0.5**	**0.3**	**0.4**	**0.4**	**NA**	**NA**	**0.5**	**NA**	**0.4**	**0.4**	**0.4**	**0.1**
Standard Deviation	**0.2**	**0.1**	**0.1**	**0.2**	**NA**	**NA**	**0.1**	**NA**	**0.0**	**0.2**	**0.0**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	0.4	0.4	0.3	0.2	NC	NC	0.6	NC	0.6	0.2	0.4	0.2
HGRK-PRTMWI07	0.2	0.3	0.8	0.8	NC	NC	0.5	NC	0.5	0.6	0.5	0.2
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	0.4	0.2	0.4	0.3	NC	NC	0.5	NC	0.4	0.2	0.3	0.1
HGRK-PRTMWI09	0.4	0.4	0.9	0.4	NC	NC	0.5	NC	1.1	0.6	0.6	0.3
Average - all wells for each month	**0.4**	**0.3**	**0.4**	**0.3**	**NC**	**0.5**	**0.5**	**NC**	**0.3**	**0.3**	**0.4**	**0.1**
Standard Deviation of individual results from monthly average	**0.1**	**0.1**	**0.2**	**0.2**	**NC**	**0.1**	**0.1**	**NC**	**0.1**	**0.2**	**0.1**	

NC= NOT COLLECTED

Er[illegible] Note: The July 1998 DO for Monitoring well HGRK-PRTMWD16 is believed to be in error.

TABLE 4-17
DISSOLVED OXYGEN CONCENTRATION SUMMARY

Well No.	OXIDATION-REDUCTION POTENTIAL SUMMARY										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	0.4	0.3	0.5	NC	NC	0.7	0.3	NC	0.2	0.2	0.4	0.2
HGRK-PRTMWD15	0.4	0.2	0.2	NC	NC	0.6	0.3	NC	0.3	0.2	0.3	0.1
HGRK-PRTMWD19	0.4	0.2	0.2	NC	NC	0.7	0.2	NC	0.2	0.2	0.3	0.2
Average for Deep Wells	**0.4**	**0.2**	**0.3**	**NA**	**NA**	**0.7**	**0.3**	**NA**	**0.2**	**0.2**	**0.3**	**0.2**
Standard Deviation	**0.0**	**0.1**	**0.2**	**NA**	**NA**	**0.1**	**0.1**	**NA**	**0.0**	**0.0**	**0.0**	
HGRK-PRTMWI13	0.2	0.2	0.4	0.2	NC	NC	0.5	NC	0.3	0.4	0.3	0.1
HGRK-PRTMWI15	0.4	0.1	0.2	0.2	NC	NC	0.6	NC	0.4	0.4	0.3	0.2
HGRK-PRTMWI19	0.4	0.1	0.3	0.2	NC	NC	0.3	NC	0.3	0.2	0.3	0.1
Average for Intermediate Wells	**0.3**	**0.1**	**0.3**	**0.2**	**NA**	**NA**	**0.5**	**NA**	**0.3**	**0.3**	**0.3**	**0.1**
Standard Deviation	**0.1**	**0.1**	**0.1**	**0.0**	**NA**	**NA**	**0.2**	**NA**	**0.1**	**0.1**	**0.0**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	0.2	0.1	0.4	0.3	NC	0.6	0.4	NC	0.2	0.2	0.3	0.2
HGRK-PRTMWD16	0.2	0.1	0.3	0.3	NC	Err	0.2	NC	0.2	0.3	0.2	0.1
HGRK-PRTMWD20	0.2	0.3	0.5	0.3	NC	0.8	0.2	NC	0.2	0.2	0.3	0.2
Average for Deep Wells	**0.2**	**0.2**	**0.4**	**0.3**	**NA**	**0.7**	**0.3**	**NA**	**0.2**	**0.2**	**0.3**	**0.2**
Standard Deviation	**0.0**	**0.1**	**0.1**	**0.0**	**NA**	**0.1**	**0.1**	**NA**	**0.0**	**0.1**	**0.1**	
HGRK-PRTMWI14	0.4	0.3	0.3	0.2	NC	NC	0.5	NC	0.4	0.2	0.3	0.1
HGRK-PRTMWI16	0.2	0.2	0.3	0.2	NC	NC	0.5	NC	0.6	0.2	0.3	0.2
HGRK-PRTMWI20	0.2	0.4	0.2	0.4	NC	NC	0.5	NC	0.3	0.2	0.3	0.1
Average for Intermediate Wells	**0.3**	**0.3**	**0.3**	**0.3**	**NA**	**NA**	**0.5**	**NA**	**0.4**	**0.2**	**0.3**	**0.1**
Standard Deviation	**0.1**	**0.1**	**0.1**	**0.1**	**NA**	**NA**	**0.0**	**NA**	**0.1**	**0.0**	**0.0**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	0.4	0.4	0.2	0.2	NC	NC	0.3	NC	0.6	0.3	0.3	0.1
HGRK-PRTMWI17	0.2	0.3	0.4	0.4	NC	NC	0.6	NC	0.4	0.4	0.4	0.1
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	0.4	0.2	0.3	0.2	NC	NC	0.4	NC	0.2	0.2	0.3	0.1
HGRK-PRTMWI18	0.2	0.3	0.4	0.5	NC	NC	0.6	NC	0.4	0.6	0.4	0.1
Average - all wells for each month	**0.3**	**0.2**	**0.3**	**0.3**	**NC**	**0.7**	**0.4**	**NC**	**0.3**	**0.3**	**0.3**	**0.1**
Standard Deviation of individual results from monthly average	**0.1**	**0.1**	**0.1**	**0.1**	**NC**	**0.1**	**0.1**	**NC**	**0.1**	**0.1**	**0.1**	

NC= NOT COLLECTED

Err Note: The July 1998 DO for Monitoring well HGRK-PRTMWD16 is believed to be in error.

TABLE 4-18
ALKALINITY (mg/L as CaCO3) CONCENTRATION SUMMARY

Well No.	ALKALINITY (mg/L as CaCO3) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	440	480	440	420	460	440	460	460	400	420	442	24
HGRK-PRTMWD03	420	440	460	460	460	440	440	NC	440	460	447	14
HGRK-PRTMWD11	360	420	400	400	440	400	440	400	400	400	406	23
Average for Deep Wells	**407**	**447**	**433**	**427**	**453**	**427**	**447**	**430**	**413**	**427**	**432**	**15**
Standard Deviation	**42**	**31**	**31**	**31**	**12**	**23**	**12**	**42**	**23**	**31**	**22**	
HGRK-PRTMWI01	187	180	180	180	180	160	180	180	180	160	177	9
HGRK-PRTMWI03	187	180	160	180	180	180	180	180	180	180	179	7
HGRK-PRTMWI11	200	200	205	180	180	180	180	180	180	160	185	13
Average for Intermediate Wells	**191**	**187**	**182**	**180**	**180**	**173**	**180**	**180**	**180**	**167**	**180**	**7**
Standard Deviation	**8**	**12**	**23**	**0**	**0**	**12**	**0**	**0**	**0**	**12**	**4**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	360	400	400	380	380	380	360	380	360	360	376	16
HGRK-PRTMWD05	440	480	440	400	420	380	440	400	400	400	420	30
HGRK-PRTMWD12	280	260	NC	200	220	180	200	400	180	160	231	74
Average for Deep Wells	**360**	**380**	**420**	**327**	**340**	**313**	**333**	**393**	**313**	**307**	**342**	**38**
Standard Deviation	**80**	**111**	**28**	**110**	**106**	**115**	**122**	**12**	**117**	**129**	**99**	
HGRK-PRTMWI02	45	40	30	40	35	35	35	40	40	50	39	6
HGRK-PRTMWI05	60	35	35	35	35	30	35	35	40	45	39	9
HGRK-PRTMWI12	15	119	35	35	35	35	35	40	35	45	43	28
Average for Intermediate Wells	**40**	**65**	**33**	**37**	**35**	**33**	**35**	**38**	**38**	**47**	**40**	**9**
Standard Deviation	**23**	**47**	**3**	**3**	**0**	**3**	**0**	**3**	**3**	**3**	**2**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	260	260	240	220	240	220	260	260	240	220	242	18
HGRK-PRTMWI07	40	35	30	35	35	30	35	35	45	40	36	5
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	380	340	320	360	380	360	380	NC	300	280	344	37
HGRK-PRTMWI09	40	119	34	180	35	30	40	35	35	30	58	51
Average - all wells for each month	**232**	**249**	**227**	**232**	**232**	**218**	**231**	**216**	**216**	**213**	**229**	**158**
Standard Deviation of individual results from monthly average	**157**	**160**	**171**	**152**	**169**	**160**	**168**	**165**	**151**	**154**	**11**	

NC= NOT COLLECTED

TABLE 4-18
ALKALINITY (mg/L as CaCO3) CONCENTRATION SUMMARY

Well No.	ALKALINITY (mg/L as CaCO3) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	420	420	NC	400	400	420	420	400	380	380	404	17
HGRK-PRTMWD15	420	380	380	400	400	380	400	400	400	380	394	13
HGRK-PRTMWD19	360	380	400	340	360	380	360	420	360	380	374	23
Average for Deep Wells	**400**	**393**	**390**	**380**	**387**	**393**	**393**	**407**	**380**	**380**	**391**	**9**
Standard Deviation	**35**	**23**	**14**	**35**	**23**	**23**	**31**	**12**	**20**	**0**	**15**	
HGRK-PRTMWI13	180	200	160	200	200	180	200	180	180	160	184	16
HGRK-PRTMWI15	200	200	180	220	220	200	200	180	180	180	196	16
HGRK-PRTMWI19	160	180	160	160	160	160	180	160	160	160	164	8
Average for Intermediate Wells	**180**	**193**	**167**	**193**	**193**	**180**	**193**	**173**	**173**	**167**	**181**	**11**
Standard Deviation	**20**	**12**	**12**	**31**	**31**	**20**	**12**	**12**	**12**	**12**	**16**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	320	380	320	320	340	320	320	320	320	300	326	21
HGRK-PRTMWD16	360	400	360	320	440	380	410	420	500	520	411	63
HGRK-PRTMWD20	420	440	440	400	440	400	410	380	400	360	409	27
Average for Deep Wells	**367**	**407**	**373**	**347**	**407**	**367**	**380**	**373**	**407**	**393**	**382**	**21**
Standard Deviation	**50**	**31**	**61**	**46**	**58**	**42**	**52**	**50**	**90**	**114**	**49**	
HGRK-PRTMWI14	80	65	55	65	60	60	60	55	45	40	59	11
HGRK-PRTMWI16	300	140	80	65	65	65	60	50	70	65	96	76
HGRK-PRTMWI20	238	240	300	380	440	380	400	320	340	320	336	66
Average for Intermediate Wells	**206**	**148**	**145**	**170**	**188**	**168**	**173**	**142**	**152**	**142**	**163**	**22**
Standard Deviation	**113**	**88**	**135**	**182**	**218**	**183**	**196**	**154**	**164**	**155**	**150**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	320	400	400	420	380	400	460	480	400	440	410	44
HGRK-PRTMWI17	800	220	260	240	140	120	25	80	120	100	211	220
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	260	340	320	360	360	340	460	460	440	380	372	65
HGRK-PRTMWI18	135	110	180	35	180	140	110	100	120	100	121	42
Average - all wells for each month	**311**	**281**	**266**	**270**	**287**	**270**	**280**	**275**	**276**	**267**	**279**	**128**
Standard Deviation of individual results from monthly average	**168**	**124**	**123**	**132**	**137**	**132**	**157**	**156**	**147**	**150**	**13**	

NC= NOT COLLECTED

TABLE 4-19
EXPLOSIMETER READING % SUMMARY

Well No.	EXPLOSIMETER READING (% OF LEL) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
MANDREL WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD01	2%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%
HGRK-PRTMWD03	4%	1%	1%	0%	1%	0%	0%	0%	0%	0%	1%	1%
HGRK-PRTMWD11	2%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%
Average for Deep Wells	**3%**	**1%**	**1%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**
Standard Deviation	**1%**	**1%**	**1%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	
HGRK-PRTMWI01	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
HGRK-PRTMWI03	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
HGRK-PRTMWI11	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Average for Intermediate Wells	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Standard Deviation	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD02	4%	0%	0%	0%	2%	0%	0%	0%	0%	10%	2%	3%
HGRK-PRTMWD05	2%	7%	7%	0%	1%	0%	3%	0%	38%	10%	7%	12%
HGRK-PRTMWD12	1%	1%	1%	0%	3%	4%	0%	8%	0%	0%	2%	3%
Average for Deep Wells	**2%**	**3%**	**3%**	**0%**	**2%**	**1%**	**1%**	**3%**	**13%**	**7%**	**3%**	**4%**
Standard Deviation	**2%**	**4%**	**4%**	**0%**	**1%**	**2%**	**2%**	**5%**	**22%**	**6%**	**3%**	
HGRK-PRTMWI02	0%	1%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%
HGRK-PRTMWI05	0%	2%	2%	0%	1%	0%	0%	6%	0%	0%	1%	2%
HGRK-PRTMWI12	0%	0%	0%	0%	1%	0%	0%	2%	7%	7%	2%	3%
Average for Intermediate Wells	**0%**	**1%**	**1%**	**0%**	**1%**	**0%**	**0%**	**3%**	**2%**	**2%**	**1%**	**1%**
Standard Deviation	**0%**	**1%**	**1%**	**0%**	**0%**	**0%**	**0%**	**3%**	**4%**	**4%**	**1%**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD07	17%	90%	90%	18%	5%	0%	32%	0%	0%	6%	26%	35%
HGRK-PRTMWI07	0%	0%	0%	0%	1%	38%	0%	0%	0%	8%	5%	12%
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD09	2%	4%	4%	1%	3%	0%	2%	2%	0%	1%	2%	1%
HGRK-PRTMWI09	1%	3%	3%	6%	5%	0%	0%	7%	0%	27%	5%	8%
Average - all wells for each month	**2%**	**7%**	**7%**	**2%**	**2%**	**3%**	**2%**	**2%**	**3%**	**4%**	**3%**	**6%**
Standard Deviation of individual results from monthly average	**4%**	**22%**	**22%**	**5%**	**1%**	**9%**	**8%**	**3%**	**10%**	**7%**	**2%**	

TABLE 4-19
EXPLOSIMETER READING % SUMMARY

Well No.	EXPLOSIMETER READING (% OF LEL) EACH SAMPLING EVENT										Average for each well, all months	Standard Deviation of each monthly reading from the 10-month average by well
	Feb-98	Mar-98	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98		
JAG WALL												
WELLS UPGRADIENT OF WALL SEGMENTS												
HGRK-PRTMWD13	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
HGRK-PRTMWD15	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	0%	0%
HGRK-PRTMWD19	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Average for Deep Wells	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Standard Deviation	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**1%**	**0%**	
HGRK-PRTMWI13	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
HGRK-PRTMWI15	2%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%
HGRK-PRTMWI19	15%	6%	6%	0%	1%	5%	46%	224%	339%	324%	97%	141%
Average for Intermediate Wells	**6%**	**2%**	**2%**	**0%**	**1%**	**2%**	**15%**	**75%**	**113%**	**108%**	**32%**	**47%**
Standard Deviation	**8%**	**3%**	**3%**	**0%**	**0%**	**3%**	**27%**	**129%**	**196%**	**187%**	**56%**	
WELLS DOWNGRADIENT OF FIRST WALL SEGMENT												
HGRK-PRTMWD14	3%	0%	0%	1%	3%	0%	3%	7%	40%	6%	6%	12%
HGRK-PRTMWD16	3%	4%	4%	1%	14%	29%	5%	6%	0%	25%	9%	10%
HGRK-PRTMWD20	0%	0%	0%	0%	1%	0%	1%	0%	1%	3%	1%	1%
Average for Deep Wells	**2%**	**1%**	**1%**	**1%**	**6%**	**10%**	**3%**	**4%**	**14%**	**11%**	**5%**	**5%**
Standard Deviation	**2%**	**2%**	**2%**	**1%**	**7%**	**17%**	**2%**	**4%**	**23%**	**12%**	**4%**	
HGRK-PRTMWI14	7%	3%	3%	0%	2%	1%	1%	9%	11%	3%	4%	4%
HGRK-PRTMWI16	44%	22%	22%	29%	22%	122%	105%	47%	98%	58%	57%	38%
HGRK-PRTMWI20	0%	2%	2%	9%	6%	141%	3%	0%	412%	2%	58%	132%
Average for Intermediate Wells	**17%**	**9%**	**9%**	**13%**	**10%**	**88%**	**36%**	**19%**	**174%**	**21%**	**40%**	**53%**
Standard Deviation	**24%**	**11%**	**11%**	**15%**	**11%**	**76%**	**59%**	**25%**	**211%**	**32%**	**31%**	
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD17	0%	1%	1%	0%	1%	0%	0%	0%	1%	0%	0%	1%
HGRK-PRTMWI17	14%	71%	71%	349%	244%	241%	71%	85%	145%	138%	143%	104%
WELLS DOWNGRADIENT OF SECOND WALL SEGMENT												
HGRK-PRTMWD18	0%	1%	1%	0%	1%	0%	1%	0%	25%	0%	3%	8%
HGRK-PRTMWI18	1%	1%	1%	0%	1%	2%	0%	1%	0%	1%	1%	1%
Average - all wells for each month	**6%**	**7%**	**7%**	**24%**	**19%**	**34%**	**15%**	**24%**	**67%**	**35%**	**24%**	**43%**
Standard Deviation of individual results from monthly average	**11%**	**18%**	**18%**	**87%**	**60%**	**71%**	**31%**	**58%**	**128%**	**85%**	**19%**	

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	NORTHING	EASTING	MEASURING POINT ELEVATION	TOTAL WELL DEPTH (Feet)	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT								
					Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)
HK2D	1511781	790801	8.36	50.00	8/7/97	5.42	2.94	2/19/98	4.33	4.03	3/16/98	4.49	3.87
HK2S	1511782	790801	8.46	35.00	8/7/97	4.73	3.73	2/19/98	3.47	4.99	3/16/98	3.67	4.79
HK5S	1511810	790817	8.72	41.00	8/7/97	4.98	3.74	2/19/98	3.77	4.95	3/16/98	3.91	4.81
HK6S	1511790	790858	8.14	35.00	8/7/97	4.39	3.75	2/19/98	3.17	4.97	3/16/98	3.33	4.81
HK7S	1511716	790893	9.43	35.00	8/7/97	5.61	3.82	2/19/98	4.38	5.05	3/16/98	4.52	4.91
HK9S	1511859	790855	8.91	35.00	8/7/97	5.17	3.74	2/19/98	3.97	4.94	3/16/98	4.13	4.78
HK10D	1511835	790790	9.13	41.00	8/7/97	5.40	3.73	2/19/98	4.23	4.90	3/16/98	4.36	4.77
HK10S	1511836	790790	9.10	35.00	8/7/97	5.36	3.74	2/19/98	4.13	4.97	3/16/98	4.34	4.76
HK11S	1511822	790744	9.18	35.00	8/7/97	5.50	3.68	2/19/98	4.24	4.94	3/16/98	4.40	4.78
HK15D	1511713	790753	8.30	51.00	8/7/97	5.38	2.92	2/19/98	4.32	3.98	3/16/98	4.50	3.80
HK15S	1511714	790754	8.26	35.00	8/7/97	4.50	3.76	2/19/98	3.28	4.98	3/16/98	3.42	4.84
HK16D	1511892	790881	8.64	51.00	8/7/97	5.65	2.99	2/19/98	4.63	4.01	3/16/98	4.77	3.87
HK16S	1511892	790881	8.64	35.00	8/7/97	4.91	3.73	2/19/98	3.72	4.92	3/16/98	3.94	4.70
HK17D	1511758	790836	8.03	50.00	8/7/97	5.17	2.86	2/19/98	4.01	4.02	3/16/98	4.19	3.84
HK18D	1511927	790830	9.18	40.00	8/7/97	5.51	3.67	2/19/98	4.36	4.82	3/16/98	4.48	4.70
HK18S	1511926	790830	9.19	35.00	8/7/97	5.50	3.69	2/19/98	4.28	4.91	3/16/98	4.48	4.71
HK19D	1511955	790790	8.85	41.00	8/7/97	5.18	3.67	2/19/98	4.06	4.79	3/16/98	4.20	4.65
HK19S	1511954	790789	8.80	35.00	8/7/97	5.11	3.69	2/19/98	3.96	4.84	3/16/98	4.14	4.66
HK20D	1512012	790818	8.58	51.00	8/7/97	5.61	2.97	2/19/98	4.63	3.95	3/16/98	4.80	3.78
HK20S	1512012	790818	8.54	35.00	8/7/97	4.84	3.70	2/19/98	3.72	4.82	3/16/98	3.91	4.63
HK21D	1511845	790713	8.72	51.00	8/7/97	5.78	2.94	2/19/98	4.81	3.91	3/16/98	4.96	3.76
HK21S	1511844	790712	8.79	35.00	8/7/97	5.15	3.64	2/19/98	3.91	4.88	3/16/98	4.09	4.70
HK22D	1512022	790346	9.41	51.00	8/7/97	6.85	2.56	2/19/98	5.96	3.45	3/16/98	6.20	3.21
HK22S	1512021	790347	9.46	35.00	8/7/97	6.29	3.17	2/19/98	5.22	4.24	3/16/98	5.35	4.11
MW104	1511992	791043	8.55	34.00	8/7/97	4.62	3.93	2/19/98	3.78	4.77	3/16/98	3.92	4.63
MW16DD	1511748	790830	7.85	54.00	8/7/97	4.83	3.02	2/19/98	3.83	4.02	3/16/98	3.92	3.93
MWD16	1511752	790832	7.74	40.00	8/7/97	3.99	3.75	2/19/98	2.82	4.92	3/16/98	2.91	4.83

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	NORTHING	EASTING	MEASURING POINT ELEVATION	TOTAL WELL DEPTH (Feet)	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT										
					Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)	
MWI16	1511756	790835	7.69	*33.00*	8/7/97	3.90	3.79	2/19/98	2.72	4.97		3/16/98	2.81	4.88	.
MWI19	1512029	790696	8.60	*36.00*	8/7/97	5.08	3.52	2/19/98	3.97	4.63		3/16/98	4.07	4.53	
MWI20	1511801	791102	10.90	*35.00*	8/7/97	7.14	3.76	2/19/98	6.06	4.84		3/16/98	6.16	4.74	
MWD20	1511796	791099	10.73	*49.00*	8/7/97	7.11	3.62	2/19/98	6.05	4.68		3/16/98	6.15	4.58	
MWI22	1511887	790958	9.36	*32.50*	8/7/97	5.58	3.78	2/19/98	4.50	4.86		3/16/98	4.62	4.74	
MWD22	1511894	790962	9.43	*50.50*	8/7/97	6.23	3.20	2/19/98	5.27	4.16	/LL	3/16/98	5.38	4.05	
MWI23	1511932	791137	9.03	*32.00*	8/7/97	5.28	3.75	2/19/98	NC	NC		3/16/98	4.42	4.61	
MWD23	1511935	791133	8.91	*48.00*	8/7/97	5.25	3.66	2/19/98	4.18	4.73		3/16/98	4.31	4.60	
MWI24	1512221	790985	9.60	*35.50*	8/7/97		NC	2/19/98	NC	NC		3/16/98	5.18	4.42	
HGRK-PRTMWD01	1511851	790761	8.76	39.02	NI	NI	NI	2/19/98	3.94	4.82		3/16/98	3.97	4.79	
HGRK-PRTMWI01	1511852	790762	8.76	19.00	NI	NI	NI	2/19/98	3.89	4.87		3/16/98	3.97	4.79	
HGRK-PRTMWD02	1511854	790757	8.75	39.68	NI	NI	NI	2/19/98	3.92	4.83		3/16/98	3.97	4.78	
HGRK-PRTMWI02	1511856	790758	8.75	19.42	NI	NI	NI	2/19/98	3.84	4.91		3/16/98	3.94	4.81	
HGRK-PRTMWD03	1511860	790769	8.80	39.45	NI	NI	NI	2/19/98	3.91	4.89		3/16/98	4.01	4.79	
HGRK-PRTMWI03	1511861	790770	8.80	19.05	NI	NI	NI	2/19/98	3.91	4.89		3/16/98	3.99	4.81	
HGRK-PRTMWD05	1511864	790767	8.77	39.51	NI	NI	NI	2/19/98	3.93	4.84		3/16/98	4.03	4.74	
HGRK-PRTMWI05	1511866	790768	8.77	19.20	NI	NI	NI	2/19/98	3.89	4.88		3/16/98	3.97	4.80	
HGRK-PRTMWD07	1511866	790764	8.76	39.54	NI	NI	NI	2/19/98	3.92	4.84		3/16/98	4.02	4.74	
HGRK-PRTMWI07	1511868	790765	8.79	19.04	NI	NI	NI	2/19/98	3.91	4.88		3/16/98	4.01	4.78	
HGRK-PRTMWD09	1511870	790761	8.77	39.38	NI	NI	NI	2/19/98	3.95	4.82		3/16/98	4.04	4.73	
HGRK-PRTMWI09	1511870	790762	8.76	20.30	NI	NI	NI	2/19/98	3.91	4.85		3/16/98	4.00	4.76	
HGRK-PRTMWD11	1511873	790782	8.85	38.81	NI	NI	NI	2/19/98	3.99	4.86		3/16/98	4.07	4.78	
HGRK-PRTMWI11	1511875	790783	8.84	18.92	NI	NI	NI	2/19/98	3.99	4.85		3/16/98	4.07	4.77	
HGRK-PRTMWD12	1511877	790778	8.74	39.82	NI	NI	NI	2/19/98	3.92	4.82		3/16/98	4.00	4.74	
HGRK-PRTMWI12	1511879	790779	8.84	20.01	NI	NI	NI	2/19/98	3.99	4.85		3/16/98	4.08	4.76	
HGRK-PRTMWD13	1511888	790795	8.88	39.16	NI	NI	NI	2/19/98	4.09	4.79		3/16/98	4.18	4.70	
HGRK-PRTMWI13	1511889	790796	8.86	19.40	NI	NI	NI	2/19/98	4.12	4.74	/C	3/16/98	4.20	4.66	/C

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	NORTHING	EASTING	MEASURING POINT ELEVATION	TOTAL WELL DEPTH (Feet)	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT								
					Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)
HGRK-PRTMWD14	1511891	790792	8.83	39.30	NI	NI	NI	2/19/98	4.01	4.82	3/16/98	4.12	4.71
HGRK-PRTMWI14	1511892	790794	8.82	19.32	NI	NI	NI	2/19/98	4.02	4.80	3/16/98	4.10	4.72
HGRK-PRTMWD15	1511897	790803	8.85	39.37	NI	NI	NI	2/19/98	4.00	4.85	3/16/98	4.10	4.75
HGRK-PRTMWI15	1511898	790804	8.88	19.30	NI	NI	NI	2/19/98	4.01	4.87	3/16/98	4.10	4.78
HGRK-PRTMWD16	1511901	790801	8.86	38.74	NI	NI	NI	2/19/98	4.03	4.83	3/16/98	4.14	4.72
HGRK-PRTMWI16	1511902	790803	8.84	19.88	NI	NI	NI	2/19/98	4.01	4.83	3/16/98	4.10	4.74
HGRK-PRTMWD17	1511903	790797	8.86	39.00	NI	NI	NI	2/19/98	4.04	4.82	3/16/98	4.14	4.72
HGRK-PRTMWI17	1511904	790799	8.86	19.30	NI	NI	NI	2/19/98	4.04	4.82	3/16/98	4.12	4.74
HGRK-PRTMWD18	1511906	790795	8.84	39.14	NI	NI	NI	2/19/98	4.03	4.81	3/16/98	4.14	4.70
HGRK-PRTMWI18	1511907	790796	8.80	19.02	NI	NI	NI	2/19/98	4.01	4.79	3/16/98	4.10	4.70
HGRK-PRTMWD19	1511911	790816	8.92	39.34	NI	NI	NI	2/19/98	4.09	4.83	3/16/98	4.19	4.73
HGRK-PRTMWI19	1511912	790817	8.92	19.00	NI	NI	NI	2/19/98	4.09	4.83	3/16/98	4.19	4.73
HGRK-PRTMWD20	1511913	790812	8.81	39.41	NI	NI	NI	2/19/98	4.02	4.79	3/16/98	4.10	4.71
HGRK-PRTMWI20	1511915	790814	8.91	19.21	NI	NI	NI	2/19/98	4.11	4.80	3/16/98	4.21	4.70
Notes								1. Heavy Rain on 2/15 and 2/16 2. Italicized total depths are based on historical information.					

NC= Data not collected

NI = Wells not installed at time of measurement

/C = Water Levels from HGRK-PRTWMI13 not used for Feb 98 to August 98. It was determined that the casing had been pulled loose in the well vault. Data from August 1998 correct after cap reset and surveyed.

/L = Water Level measuremetents believed to be inaccurate - possible malfuction with water level tape reading 9.xx when it should have read 6. xx. Data not used for water level contours.

/LL = Water Level measuremetents believed to be inaccurate. Data not used for water level contours.

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT															
	Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)	
HK2D	4/13/98	5.00	3.36		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK2S	4/13/98	4.19	4.27		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK5S	4/13/98	4.46	4.26		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK6S	4/13/98	3.87	4.27		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK7S	4/13/98	5.08	4.35		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK9S	4/13/98	4.70	4.21		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK10D	4/13/98	4.92	4.21		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK10S	4/13/98	4.87	4.23		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK11S	4/13/98	4.96	4.22		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK15D	4/13/98	4.99	3.31		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK15S	4/13/98	3.98	4.28		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK16D	4/13/98	5.32	3.32		5/18/98	NC	NC		6/15/98	6.28	2.36		7/13/98	6.23	2.41	
HK16S	4/13/98	4.43	4.21		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK17D	4/13/98	4.68	3.35		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK18D	4/13/98	5.02	4.16		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK18S	4/13/98	5.01	4.18		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK19D	4/13/98	4.73	4.12		5/18/98	NC	NC		6/15/98	6.04	2.81		7/13/98	5.91	2.94	
HK19S	4/13/98	4.68	4.12		5/18/98	NC	NC		6/15/98	NC	NC		7/13/98	NC	NC	
HK20D	4/13/98	5.21	3.37		5/18/98	NC	NC		6/15/98	6.27	2.31		7/13/98	6.25	2.33	
HK20S	4/13/98	4.45	4.09		5/18/98	NC	NC		6/15/98	5.74	2.80		7/13/98	5.57	2.97	
HK21D	4/13/98	4.45	4.27	/LL	5/18/98	5.90	2.82		6/15/98	6.38	2.34		7/13/98	6.39	2.33	
HK21S	4/13/98	4.61	4.18		5/18/98	5.25	3.54		6/15/98	5.92	2.87		7/13/98	5.76	3.03	
HK22D	4/13/98	6.69	2.72		5/18/98	NC	NC		6/15/98	7.47	1.94		7/13/98	7.43	1.98	
HK22S	4/13/98	5.90	3.56		5/18/98	NC	NC		6/15/98	7.10	2.36		7/13/98	6.92	2.54	
MWI04	4/13/98	4.40	4.15		5/18/98	5.03	3.52		6/15/98	5.68	2.87		7/13/98	5.57	2.98	
MW16DD	4/13/98	4.42	3.43		5/18/98	4.92	2.93		6/15/98	5.45	2.40		7/13/98	5.47	2.38	
MWD16	4/13/98	3.46	4.28		5/18/98	4.15	3.59		6/15/98	4.79	2.95		7/13/98	4.69	3.05	

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT															
	Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)	
MWI16	4/13/98	3.37	4.32		5/18/98	4.05	3.64		6/15/98	4.70	2.99		7/13/98	4.59	3.10	
MWI19	4/13/98	4.62	3.98		5/18/98	5.92	2.68		6/15/98	5.90	2.70		7/13/98	5.80	2.80	
MWI20	4/13/98	6.62	4.28		5/18/98	7.26	3.64		6/15/98	7.91	2.99		7/13/98	7.86	3.04	
MWD20	4/13/98	6.61	4.12		5/18/98	7.22	3.51		6/15/98	7.86	2.87		7/13/98	7.81	2.92	
MWI22	4/13/98	5.13	4.23		5/18/98	5.79	3.57		6/15/98	6.31	3.05		7/13/98	6.32	3.04	
MWD22	4/13/98	5.86	3.57		5/18/98	6.40	3.03		6/15/98	6.96	2.47		7/13/98	6.93	2.50	
MWI23	4/13/98	4.85	4.18		5/18/98	5.47	3.56		6/15/98	5.99	3.04		7/13/98	6.03	3.00	
MWD23	4/13/98	4.76	4.15		5/18/98	5.37	3.54		6/15/98	6.01	2.90		7/13/98	5.94	2.97	
MWI24	4/13/98	5.67	3.93		5/18/98	6.27	3.33		6/15/98	6.93	2.67		7/13/98	6.83	2.77	
HGRK-PRTMWD01	4/13/98	4.54	4.22		5/18/98	5.21	3.55		6/15/98	5.84	2.92		7/13/98	5.72	3.04	
HGRK-PRTMWI01	4/13/98	4.53	4.23		5/18/98	5.22	3.54		6/15/98	5.85	2.91		7/13/98	5.74	3.02	
HGRK-PRTMWD02	4/13/98	4.53	4.22		5/18/98	5.21	3.54		6/15/98	5.85	2.90		7/13/98	5.73	3.02	
HGRK-PRTMWI02	4/13/98	4.50	4.25		5/18/98	5.19	3.56		6/15/98	5.83	2.92		7/13/98	5.71	3.04	
HGRK-PRTMWD03	4/13/98	4.57	4.23		5/18/98	5.24	3.56		6/15/98	5.89	2.91		7/13/98	5.77	3.03	
HGRK-PRTMWI03	4/13/98	4.55	4.25		5/18/98	5.24	3.56		6/15/98	5.87	2.93		7/13/98	5.77	3.03	
HGRK-PRTMWD05	4/13/98	4.58	4.19		5/18/98	5.24	3.53		6/15/98	5.89	2.88		7/13/98	5.76	3.01	
HGRK-PRTMWI05	4/13/98	4.54	4.23		5/18/98	5.23	3.54		6/15/98	5.86	2.91		7/13/98	5.75	3.02	
HGRK-PRTMWD07	4/13/98	4.58	4.18		5/18/98	5.24	3.52		6/15/98	5.88	2.88		7/13/98	5.76	3.00	
HGRK-PRTMWI07	4/13/98	4.54	4.25		5/18/98	5.27	3.52		6/15/98	5.90	2.89		7/13/98	5.77	3.02	
HGRK-PRTMWD09	4/13/98	4.59	4.18		5/18/98	5.27	3.50		6/15/98	5.90	2.87		7/13/98	5.79	2.98	
HGRK-PRTMWI09	4/13/98	4.56	4.20		5/18/98	5.26	3.50		6/15/98	5.89	2.87		7/13/98	5.77	2.99	
HGRK-PRTMWD11	4/13/98	4.63	4.22		5/18/98	5.31	3.54		6/15/98	5.93	2.92		7/13/98	5.82	3.03	
HGRK-PRTMWI11	4/13/98	4.63	4.21		5/18/98	5.31	3.53		6/15/98	5.94	2.90		7/13/98	5.83	3.01	
HGRK-PRTMWD12	4/13/98	4.56	4.18		5/18/98	5.23	3.51		6/15/98	5.85	2.89		7/13/98	5.75	2.99	
HGRK-PRTMWI12	4/13/98	4.64	4.20		5/18/98	5.31	3.53		6/15/98	5.96	2.88		7/13/98	5.84	3.00	
HGRK-PRTMWD13	4/13/98	4.73	4.15		5/18/98	5.41	3.47		6/15/98	6.04	2.84		7/13/98	5.93	2.95	
HGRK-PRTMWI13	4/13/98	4.75	4.11	/C	5/18/98	5.44	3.42	/C	6/15/98	6.07	2.79	/C	7/13/98	5.87	2.99	/C

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT											
	Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)
HGRK-PRTMWD14	4/13/98	4.67	4.16	5/18/98	5.35	3.48	6/15/98	5.94	2.89	7/13/98	5.86	2.97
HGRK-PRTMWI14	4/13/98	4.66	4.16	5/18/98	5.34	3.48	6/15/98	5.99	2.83	7/13/98	5.87	2.95
HGRK-PRTMWD15	4/13/98	4.64	4.21	5/18/98	5.32	3.53	6/15/98	5.97	2.88	7/13/98	5.85	3.00
HGRK-PRTMWI15	4/13/98	4.65	4.23	5/18/98	5.33	3.55	6/15/98	5.97	2.91	7/13/98	5.86	3.02
HGRK-PRTMWD16	4/13/98	4.69	4.17	5/18/98	5.35	3.51	6/15/98	6.00	2.86	7/13/98	5.87	2.99
HGRK-PRTMWI16	4/13/98	4.66	4.18	5/18/98	5.33	3.51	6/15/98	5.98	2.86	7/13/98	5.85	2.99
HGRK-PRTMWD17	4/13/98	4.76	4.10	5/18/98	5.38	3.48	6/15/98	6.00	2.86	7/13/98	5.88	2.98
HGRK-PRTMWI17	4/13/98	4.68	4.18	5/18/98	5.36	3.50	6/15/98	5.99	2.87	7/13/98	5.87	2.99
HGRK-PRTMWD18	4/13/98	4.70	4.14	5/18/98	5.38	3.46	6/15/98	6.01	2.83	7/13/98	5.87	2.97
HGRK-PRTMWI18	4/13/98	4.64	4.16	5/18/98	5.34	3.46	6/15/98	5.97	2.83	7/13/98	5.86	2.94
HGRK-PRTMWD19	4/13/98	4.74	4.18	5/18/98	5.41	3.51	6/15/98	6.05	2.87	7/13/98	5.87	3.05
HGRK-PRTMWI19	4/13/98	4.77	4.15	5/18/98	5.41	3.51	6/15/98	6.05	2.87	7/13/98	5.96	2.96
HGRK-PRTMWD20	4/13/98	4.66	4.15	5/18/98	5.34	3.47	6/15/98	5.97	2.84	7/13/98	5.94	2.87
HGRK-PRTMWI20	4/13/98	4.76	4.15	5/18/98	5.44	3.47	6/15/98	6.07	2.84	7/13/98	5.94	2.97
Notes												

NC= Data not collected

NI = Wells not installed at time of measurement

/C = Water Levels from HGRK-PRTWMI13 not used for Feb 98 to August 98. It was determined that the casing had been pulled loose in the well vault. Data from August 1998 correct after cap reset and surveyed.

/L = Water Level measuremetents believed to be inaccurate - possible malfuction with water level tape reading 9.xx when it should have read 6. xx. Data not used for water level contours.

/LL = Water Level measuremetents believed to be inaccurate. Data not used for water level contours.

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT															
	Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)	
HK2D	8/10/98	NC	NC		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	5.03	3.33	
HK2S	8/10/98	5.69	2.77		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.18	4.28	
HK5S	8/10/98	5.97	2.75		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.41	4.31	
HK6S	8/10/98	5.39	2.75		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	3.82	4.32	
HK7S	8/10/98	6.60	2.83		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	5.02	4.41	
HK9S	8/10/98	6.17	2.74		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.62	4.29	
HK10D	8/10/98	6.41	2.72		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.89	4.24	
HK10S	8/10/98	6.35	2.75		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.91	4.19	
HK11S	8/10/98	6.45	2.73		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.91	4.27	
HK15D	8/10/98	NC	NC		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.99	3.31	
HK15S	8/10/98	NC	NC		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	3.92	4.34	
HK16D	8/10/98	6.42	2.22		9/14/98	5.48	3.16		10/12/98	4.74	3.90		11/16/98	5.27	3.37	
HK16S	8/10/98	5.92	2.72		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.41	4.23	
HK17D	8/10/98	5.80	2.23		9/14/98	4.90	3.13		10/12/98	4.16	3.87		11/16/98	4.70	3.33	
HK18D	8/10/98	6.56	2.62		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.98	4.20	
HK18S	8/10/98	6.55	2.64		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.97	4.22	
HK19D	8/10/98	6.21	2.64		9/14/98	5.05	3.80		10/12/98	4.02	4.83		11/16/98	4.72	4.13	
HK19S	8/10/98	6.14	2.66		9/14/98	NC	NC		10/12/98	NC	NC		11/16/98	4.71	4.09	
HK20D	8/10/98	6.40	2.18		9/14/98	5.53	3.05		10/12/98	4.78	3.80		11/16/98	5.27	3.31	
HK20S	8/10/98	5.92	2.62		9/14/98	4.72	3.82		10/12/98	3.70	4.84		11/16/98	4.46	4.08	
HK21D	8/10/98	6.53	2.19		9/14/98	5.69	3.03		10/12/98	4.93	3.79		11/16/98	5.44	3.28	
HK21S	8/10/98	6.09	2.70		9/14/98	4.87	3.92		10/12/98	3.82	4.97		11/16/98	4.56	4.23	
HK22D	8/10/98	7.50	1.91		9/14/98	6.73	2.68		10/12/98	6.08	3.33		11/16/98	6.54	2.87	
HK22S	8/10/98	7.20	2.26		9/14/98	6.06	3.40		10/12/98	5.04	4.42		11/16/98	5.82	3.64	
MWI04	8/10/98	8.88	-0.33	/L	9/14/98	4.73	3.82		10/12/98	3.82	4.73		11/16/98	3.39	5.16	
MW16DD	8/10/98	5.59	2.26		9/14/98	4.77	3.08		10/12/98	3.97	3.88		11/16/98	4.41	3.44	/LL
MWD16	8/10/98	4.99	2.75		9/14/98	3.81	3.93		10/12/98	2.76	4.98		11/16/98	3.40	4.34	

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT															
	Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)		Date	Depth to ground water (ft)	Ground Water Elevation (ft)	
MWI16	8/10/98	4.90	2.79		9/14/98	3.71	3.98		10/12/98	2.65	5.04		11/16/98	3.29	4.40	
MWI19	8/10/98	6.00	2.60		9/14/98	4.95	3.65		10/12/98	3.90	4.70		11/16/98	4.57	4.03	
MWI20	8/10/98	8.14	2.76		9/14/98	7.00	3.90		10/12/98	6.05	4.85		11/16/98	6.60	4.30	
MWD20	8/10/98	8.01	2.72		9/14/98	6.98	3.75		10/12/98	6.05	4.68		11/16/98	6.61	4.12	
MWI22	8/10/98	6.64	2.72		9/14/98	5.47	3.89		10/12/98	4.49	4.87		11/16/98	5.09	4.27	
MWD22	8/10/98	7.10	2.33		9/14/98	6.16	3.27		10/12/98	5.36	4.07		11/16/98	5.86	3.57	
MWI23	8/10/98	9.33	-0.30	/L	9/14/98	5.20	3.83		10/12/98	4.33	4.70		11/16/98	4.94	4.09	
MWD23	8/10/98	9.23	-0.32	/L	9/14/98	5.11	3.80		10/12/98	4.24	4.67		11/16/98	4.75	4.16	
MWI24	8/10/98	7.09	2.51		9/14/98	5.96	3.64		10/12/98	5.08	4.52		11/16/98	5.64	3.96	
HGRK-PRTMWD01	8/10/98	6.03	2.73		9/14/98	4.85	3.91		10/12/98	3.80	4.96		11/16/98	4.46	4.30	
HGRK-PRTMWI01	8/10/98	6.03	2.73		9/14/98	4.87	3.89		10/12/98	3.81	4.95		11/16/98	4.45	4.31	
HGRK-PRTMWD02	8/10/98	6.03	2.72		9/14/98	4.85	3.90		10/12/98	3.80	4.95		11/16/98	4.46	4.29	
HGRK-PRTMWI02	8/10/98	6.00	2.75		9/14/98	4.84	3.91		10/12/98	3.78	4.97		11/16/98	4.43	4.32	
HGRK-PRTMWD03	8/10/98	6.06	2.74		9/14/98	4.88	3.92		10/12/98	3.84	4.96		11/16/98	4.51	4.29	
HGRK-PRTMWI03	8/10/98	6.00	2.80		9/14/98	4.91	3.89		10/12/98	3.83	4.97		11/16/98	4.48	4.32	
HGRK-PRTMWD05	8/10/98	6.04	2.73		9/14/98	4.89	3.88		10/12/98	3.84	4.93		11/16/98	4.51	4.26	
HGRK-PRTMWI05	8/10/98	6.04	2.73		9/14/98	4.88	3.89		10/12/98	3.83	4.94		11/16/98	4.47	4.30	
HGRK-PRTMWD07	8/10/98	6.05	2.71		9/14/98	4.89	3.87		10/12/98	3.82	4.94		11/16/98	4.49	4.27	
HGRK-PRTMWI07	8/10/98	6.05	2.74		9/14/98	4.91	3.88		10/12/98	3.85	4.94		11/16/98	4.50	4.29	
HGRK-PRTMWD09	8/10/98	6.08	2.69		9/14/98	4.91	3.86		10/12/98	3.86	4.91		11/16/98	4.52	4.25	
HGRK-PRTMWI09	8/10/98	6.06	2.70		9/14/98	4.91	3.85		10/12/98	3.85	4.91		11/16/98	4.49	4.27	
HGRK-PRTMWD11	8/10/98	6.05	2.80		9/14/98	4.95	3.90		10/12/98	3.91	4.94		11/16/98	4.56	4.29	
HGRK-PRTMWI11	8/10/98	6.10	2.74		9/14/98	4.96	3.88		10/12/98	3.92	4.92		11/16/98	4.55	4.29	
HGRK-PRTMWD12	8/10/98	6.03	2.71		9/14/98	4.89	3.85		10/12/98	3.84	4.90		11/16/98	4.49	4.25	
HGRK-PRTMWI12	8/10/98	6.14	2.70		9/14/98	4.99	3.85		10/12/98	3.93	4.91		11/16/98	4.57	4.27	
HGRK-PRTMWD13	8/10/98	6.15	2.73		9/14/98	5.06	3.82		10/12/98	4.02	4.86		11/16/98	4.66	4.22	
HGRK-PRTMWI13	8/10/98	6.16	2.70		9/14/98	5.00	3.86		10/12/98	3.96	4.90		11/16/98	4.59	4.27	

TABLE 4-20
WATER LEVEL MEASUREMENTS

MONITORING WELL IDENTIFICATION	WATER LEVEL MEASUREMENTS: EACH SAMPLING EVENT										
	Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)	Date	Depth to ground water (ft)	Ground Water Elevation (ft)
HGRK-PRTMWD14	8/10/98	6.15	2.68	9/14/98	5.01	3.82	10/12/98	3.97	4.86	11/16/98	4.60	4.23
HGRK-PRTMWI14	8/10/98	6.16	2.66	9/14/98	5.01	3.81	10/12/98	3.96	4.86	11/16/98	4.60	4.22
HGRK-PRTMWD15	8/10/98	6.12	2.73	9/14/98	4.99	3.86	10/12/98	3.95	4.90	11/16/98	4.58	4.27
HGRK-PRTMWI15	8/10/98	6.15	2.73	9/14/98	5.00	3.88	10/12/98	3.96	4.92	11/16/98	4.60	4.28
HGRK-PRTMWD16	8/10/98	6.15	2.71	9/14/98	5.01	3.85	10/12/98	3.99	4.87	11/16/98	4.63	4.23
HGRK-PRTMWI16	8/10/98	6.15	2.69	9/14/98	5.00	3.84	10/12/98	3.95	4.89	11/16/98	4.59	4.25
HGRK-PRTMWD17	8/10/98	6.18	2.68	9/14/98	5.02	3.84	10/12/98	3.99	4.87	11/16/98	4.63	4.23
HGRK-PRTMWI17	8/10/98	6.17	2.69	9/14/98	5.01	3.85	10/12/98	3.98	4.88	11/16/98	4.62	4.24
HGRK-PRTMWD18	8/10/98	6.20	2.64	9/14/98	5.02	3.82	10/12/98	3.98	4.86	11/16/98	4.63	4.21
HGRK-PRTMWI18	8/10/98	6.15	2.65	9/14/98	5.00	3.80	10/12/98	3.95	4.85	11/16/98	4.59	4.21
HGRK-PRTMWD19	8/10/98	6.23	2.69	9/14/98	5.07	3.85	10/12/98	4.04	4.88	11/16/98	4.68	4.24
HGRK-PRTMWI19	8/10/98	6.23	2.69	9/14/98	5.08	3.84	10/12/98	4.05	4.87	11/16/98	4.67	4.25
HGRK-PRTMWD20	8/10/98	6.15	2.66	9/14/98	4.99	3.82	10/12/98	3.98	4.83	11/16/98	4.60	4.21
HGRK-PRTMWI20	8/10/98	6.25	2.66	9/14/98	5.10	3.81	10/12/98	4.07	4.84	11/16/98	4.70	4.21
Notes												

NC= Data not collected

NI = Wells not installed at time of measurement

/C = Water Levels from HGRK-PRTWMI13 not used for Feb 98 to August 98. It was determined that the casing had been pulled loose in the well vault. Data from August 1998 correct after cap reset and surveyed.

/L = Water Level measuremetents believed to be inaccurate - possible malfuction with water level tape reading 9.xx when it should have read 6. xx. Data not used for water level contours.

/LL = Water Level measuremetents believed to be inaccurate. Data not used for water level contours.

TABLE 4-21
FLOW SENSOR DATA

Start Date	Start Time	End Date	End Time	Parameter	SENSOR LOCATION															
					PRT03		PRT05			PRT10			PRT15			PRT16		PRT21		
2/22/98	2:33	2/23/98	15:25	Vertical flow (cm/day)	1.85	*	-0.24	+/-	0.32	-0.68	+/-	0.20	-3.74	+/-	0.59	6.67	*	-9.90	+/-	1.84
				Horizontal flow (cm/day)	0.78	*	0.37	+/-	0.34	1.50	+/-	0.25	3.09	+/-	0.58	1.06	*	3.81	+/-	1.56
				Total flow (cm/day)	2.01	*	0.44	+/-	0.90	1.65	+/-	1.96	4.85	+/-	5.68	6.75	*	10.61	+/-	12.91
				Degrees from Horizontal	67.14	*	-32.97	+/-	24.60	-24.39	+/-	14.13	-50.44	+/-	24.29	80.97	*	-68.95	+/-	29.95
				Azimuth (° from North)	23.4	*	227.5	+/-	72.8	341.3	+/-	10.2	10.20	+/-	12.3	114.9	*	5.46	+/-	25.1
				ERMS	0.34		0.11			0.04			0.11			0.50		0.20		
3/8/98	0:14	3/9/98	13:13	Vertical flow (cm/day)	1.80	*	-0.33	+/-	0.33	-0.70	+/-	0.21	-5.26	+/-	0.79	7.67	*	-10.50	+/-	1.96
				Horizontal flow (cm/day)	1.05	*	0.38	+/-	0.33	1.55	+/-	0.25	4.18	+/-	0.76	1.38	*	4.43	+/-	1.63
				Total flow (cm/day)	2.08	*	0.50	+/-	0.97	1.70	+/-	2.02	6.72	+/-	7.81	7.79	*	11.40	+/-	13.86
				Degrees from Horizontal	59.74	*	-40.97	+/-	26.63	-24.30	+/-	14.17	-51.53	+/-	24.61	79.80	*	-67.12	+/-	29.57
				Azimuth (° from North)	24.0	*	237.2	+/-	75.6	344.2	+/-	10.2	10.76	+/-	10.8	120.8	*	12.50	+/-	22.5
				ERMS	0.34		0.11			0.04			0.14			0.49		0.20		
3/16/98	20:45	3/18/98	9:56	Vertical flow (cm/day)	1.84	*	-0.34	+/-	0.34	-0.74	+/-	0.21	-5.08	+/-	0.76	7.69	*	-10.81	+/-	2.02
				Horizontal flow (cm/day)	0.96	*	0.43	+/-	0.35	1.55	+/-	0.25	4.05	+/-	0.73	1.33	*	4.58	+/-	1.66
				Total flow (cm/day)	2.08	*	0.55	+/-	1.03	1.72	+/-	2.04	6.50	+/-	7.55	7.80	*	11.74	+/-	14.27
				Degrees from Horizontal	62.45	*	-38.33	+/-	25.44	-25.52	+/-	14.66	-51.44	+/-	24.57	80.19	*	-67.04	+/-	29.56
				Azimuth (° from North)	23.3	*	242.3	+/-	66.5	342.4	+/-	10.1	10.21	+/-	11.6	123.1	*	10.77	+/-	22.0
				ERMS	0.34		0.12			0.04			0.13			0.49		0.20		
3/25/98	14:30	4/15/98	8:00	Vertical flow (cm/day)	1.88	*	-0.38	+/-	0.35	-0.83	+/-	0.21	-4.66	+/-	0.68	7.45	*	-11.37	+/-	2.12
				Horizontal flow (cm/day)	0.84	*	0.44	+/-	0.35	1.60	+/-	0.24	3.55	+/-	0.66	1.18	*	4.75	+/-	1.69
				Total flow (cm/day)	2.06	*	0.58	+/-	1.08	1.80	+/-	2.11	5.86	+/-	6.80	7.54	*	12.32	+/-	14.95
				Degrees from Horizontal	65.92	*	-40.82	+/-	26.14	-27.42	+/-	15.40	-52.70	+/-	24.95	81.00	*	-67.33	+/-	29.65
				Azimuth (° from North)	22.1	*	244.7	+/-	66.3	338.9	+/-	9.6	10.52	+/-	12.0	128.5	*	7.62	+/-	21.4
				ERMS	0.34		0.12			0.04			0.12			0.48		0.20		
4/15/98	8:30	5/14/98	7:00	Vertical flow (cm/day)	1.99	*	-0.40	+/-	0.36	-0.90	+/-	0.21	-3.44	+/-	0.49	7.45	*	-11.45	+/-	2.08
				Horizontal flow (cm/day)	0.50	*	0.59	+/-	0.38	1.56	+/-	0.23	2.54	+/-	0.49	1.08	*	4.49	+/-	1.66
				Total flow (cm/day)	2.05	*	0.71	+/-	1.23	1.80	+/-	2.11	4.28	+/-	4.96	7.53	*	12.30	+/-	14.86
				Degrees from Horizontal	75.90	*	-34.14	+/-	23.00	-29.98	+/-	16.50	-53.56	+/-	25.18	81.75	*	-68.59	+/-	29.88
				Azimuth (° from North)	17.8	*	245.1	+/-	49.9	331.1	+/-	9.79	8.82	+/-	12.6	144.5	*	0.89	+/-	22.2
				ERMS	0.35		0.12			0.04			0.10			0.48		0.20		

TABLE 4-21
FLOW SENSOR DATA

Start Date	Start Time	End Date	End Time	Parameter	SENSOR LOCATION															
					PRT03		PRT05			PRT10			PRT15			PRT16		PRT21		
5/27/98	7:31	6/15/98	11:31	Vertical flow (cm/day)	1.67	*	-0.59	+/-	0.38	-0.94	+/-	0.21	-3.37	+/-	0.45	6.68	*	-11.85	+/-	2.09
				Horizontal flow (cm/day)	0.44	*	0.58	+/-	0.38	1.35	+/-	0.22	2.24	+/-	0.46	1.02	*	3.96	+/-	1.62
				Total flow (cm/day)	1.73	*	0.83	+/-	1.36	1.65	+/-	1.95	4.05	+/-	4.68	6.76	*	12.49	+/-	15.02
				Degrees from Horizontal	75.24	*	-45.49	+/-	26.26	-34.85	+/-	18.68	-56.39	+/-	25.97	81.32	*	-71.52	+/-	30.45
				Azimuth (° from North)	23.3	*	247.9	+/-	53.9	329.2	+/-	11.2	9.66	+/-	13.3	148.6	*	1.82	+/-	26.7
				ERMS	0.33		0.11			0.04			0.10			0.47		0.19		
6/18/98	6:18	7/23/98	10:00	Vertical flow (cm/day)	1.98	*	-0.53	+/-	0.36	-0.85	+/-	0.21	-3.11	+/-	0.42	7.31	*	-9.93	+/-	1.76
				Horizontal flow (cm/day)	0.50	*	0.48	+/-	0.37	1.27	+/-	0.22	2.07	+/-	0.43	1.10	*	3.47	+/-	1.48
Note: 6/15-17/98 and 7/13-16/98 removed from data set , during well sampling.				Total flow (cm/day)	2.04	*	0.72	+/-	1.23	1.53	+/-	1.83	3.74	+/-	4.33	7.39	*	10.52	+/-	12.69
				Degrees from Horizontal	75.83	*	-47.83	+/-	27.22	-33.79	+/-	18.41	-56.35	+/-	25.97	81.44	*	-70.74	+/-	30.24
				Azimuth (° from North)	20.9	*	245.3	+/-	63.3	330.4	+/-	11.3	7.15	+/-	13.5	144.9	*	0.09	+/-	27.3
				ERMS	0.34		0.11			0.04			0.10			0.49		0.20		
7/23/98	10:30	8/11/98	7:30	Vertical flow (cm/day)	2.04	*	-0.53	+/-	0.35	-0.99	+/-	0.24	-3.08	+/-	0.42	7.39	*	-9.37	+/-	1.66
				Horizontal flow (cm/day)	0.52	*	0.44	+/-	0.36	1.09	+/-	0.24	2.05	+/-	0.42	1.06	*	3.19	+/-	1.43
				Total flow (cm/day)	2.11	*	0.69	+/-	1.19	1.47	+/-	1.81	3.70	+/-	4.28	7.47	*	9.90	+/-	11.96
				Degrees from Horizontal	75.70	*	-50.30	+/-	27.94	-42.25	+/-	22.00	-56.35	+/-	26.00	81.84	*	-71.20	+/-	30.31
				Azimuth (° from North)	21.9	*	243.9	+/-	68.6	330.9	+/-	14.5	6.98	+/-	13.5	140.5	*	1.26	+/-	29.6
				ERMS	0.35		0.11			0.04			0.09			0.49		0.20		
8/14/98	8:00	9/14/98	8:30	Vertical flow (cm/day)	2.04	*	-0.51	+/-	0.35	-0.75	+/-	0.21	-3.17	+/-	0.43	7.52	*	-9.17	+/-	1.63
				Horizontal flow (cm/day)	0.68	*	0.35	+/-	0.35	1.17	+/-	0.22	2.18	+/-	0.44	1.07	*	3.11	+/-	1.41
				Total flow (cm/day)	2.15	*	0.62	+/-	1.11	1.39	+/-	1.69	3.85	+/-	4.45	7.60	*	9.68	+/-	11.71
				Degrees from Horizontal	71.57	*	-55.54	+/-	29.86	-32.66	+/-	18.17	-55.48	+/-	25.71	81.90	*	-71.27	+/-	30.32
				Azimuth (° from North)	20.9	*	244.8	+/-	84.6	336.1	+/-	12.1	6.6	+/-	13.1	137.7	*	0.9	+/-	30.2
				ERMS	0.35		0.11			0.04			0.09			0.49		0.20		
9/17/98	0:00	10/13/98	7:30	Vertical flow (cm/day)	1.87	*	-0.49	+/-	0.32	-0.83	+/-	0.21	-4.91	+/-	0.67	7.29	*	-10.65	+/-	1.92
				Horizontal flow (cm/day)	1.15	*	0.23	+/-	0.32	1.39	+/-	0.24	3.53	+/-	0.64	1.16	*	4.22	+/-	1.58
				Total flow (cm/day)	2.20	*	0.54	+/-	0.98	1.62	+/-	1.93	6.05	+/-	6.97	7.38	*	11.46	+/-	13.84
				Degrees from Horizontal	58.41	*	-64.86	+/-	32.19	-30.84	+/-	17.02	-54.29	+/-	25.39	80.96	*	-68.38	+/-	29.79
				Azimuth (° from North)	18.9	*	257.0	+/-	120.9	344.1	+/-	10.8	8.35	+/-	11.7	114.7	*	7.2	+/-	22.9
				ERMS	0.34		0.11			0.04			0.12			0.50		0.19		

TABLE 4-21
FLOW SENSOR DATA

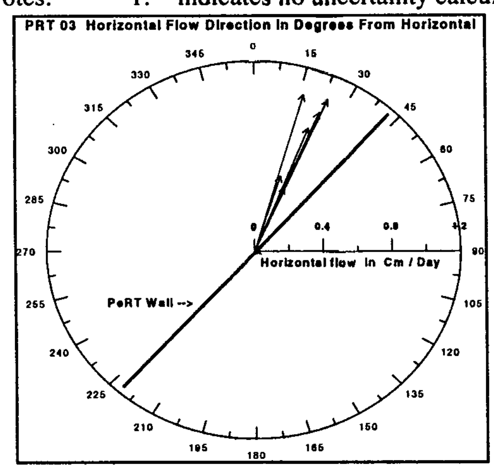
Start Date	Start Time	End Date	End Time	Parameter	SENSOR LOCATION															
					PRT03		PRT05			PRT10			PRT15			PRT16		PRT21		
10/15/98	0:00	11/16/98	11:30	Vertical flow (cm/day)	2.01	*	-0.38	+/-	0.34	-0.78	+/-	0.21	-4.76	+/-	0.66	7.17	*	-11.28	+/-	2.06
				Horizontal flow (cm/day)	1.03	*	0.33	+/-	0.34	1.45	+/-	0.24	3.53	+/-	0.63	1.13	*	4.70	+/-	1.66
				Total flow (cm/day)	2.26	*	0.50	+/-	0.98	1.65	+/-	1.96	5.93	+/-	6.83	7.26	*	12.22	+/-	14.78
				Degrees from Horizontal	62.87	*	-49.03	+/-	28.96	-28.28	+/-	15.94	-53.44	+/-	25.14	81.04	*	-67.38	+/-	29.61
				Azimuth (° from North)	16.2	*	258.9	+/-	91.9	340.0	+/-	10.5	7.6	+/-	11.6	121.7	*	4.8	+/-	21.4
				ERMS	0.34		0.11			0.04			0.12			0.50		0.19		

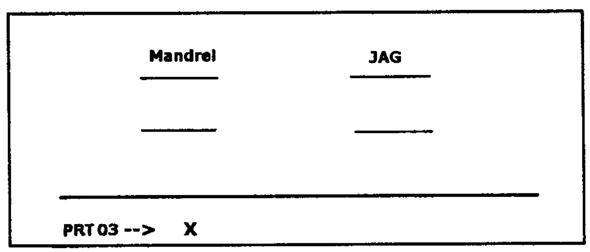
Notes: 1: * indicates no uncertainty calculated because ERMS value is above 0.30.
2: ERMS indicates Error Root Mean Square. It is derived by fitting the data to a theoretical curve.
3: An additional ± 10% error should be added to the azimuth related to installation of the probes (Ballard, 1996)

TABLE 4-22
RESULTS FOR FLOW SENSOR AT LOCATION PRT 03

Start Date	Start Time	End Date	End Time	Parameter: Vertical flow (cm/day)	Horizontal flow (cm/day)	Total flow (cm/day)	Degrees from Horizontal	Azimuth (° from North)	ERMS
2/22/98	2:33	2/23/98	15:25	1.85 +/- *	0.78 +/- *	2.01 +/- *	67.1 +/- *	23.4 +/- *	0.34
3/8/98	0:14	3/9/98	13:13	1.80 +/- *	1.05 +/- *	2.08 +/- *	59.7 +/- *	24.0 +/- *	0.34
3/16/98	20:45	3/18/98	9:56	1.84 +/- *	0.96 +/- *	2.08 +/- *	62.4 +/- *	23.3 +/- *	0.34
3/25/98	14:30	4/15/98	8:00	1.88 +/- *	0.84 +/- *	2.06 +/- *	65.9 +/- *	22.1 +/- *	0.34
4/15/98	8:30	5/14/98	7:00	1.99 +/- *	0.50 +/- *	2.05 +/- *	75.9 +/- *	17.8 +/- *	0.35
5/27/98	7:31	6/15/98	11:31	1.67 +/- *	0.44 +/- *	1.73 +/- *	75.2 +/- *	23.3 +/- *	0.33
6/18/98	6:18	7/23/98	10:00	1.98 +/- *	0.50 +/- *	2.04 +/- *	75.8 +/- *	20.9 +/- *	0.34
7/23/98	10:30	8/11/98	7:30	2.04 +/- *	0.52 +/- *	2.11 +/- *	75.7 +/- *	21.9 +/- *	0.35
8/14/98	8:00	9/14/98	8:30	2.04 +/- *	0.68 +/- *	2.15 +/- *	71.6 +/- *	20.9 +/- *	0.35
9/17/98	0:00	10/13/98	7:30	1.87 +/- *	1.15 +/- *	2.20 +/- *	58.4 +/- *	18.9 +/- *	0.34
10/15/98	0:00	11/16/98	11:30	2.01 +/- *	1.03 +/- *	2.26 +/- *	62.9 +/- *	16.2 +/- *	0.34
Average				1.91 +/- *	0.77 +/- *	2.07 +/- *	68.3 +/- *	21.2 +/- *	0.34
Standard Deviation				0.116	0.26	0.13	6.9	2.5	0.01

Notes: 1: * indicates no uncertainty calculated because ERMS value is above 0.30.





NOTE: PeRT Wall Oriented at North 410 East

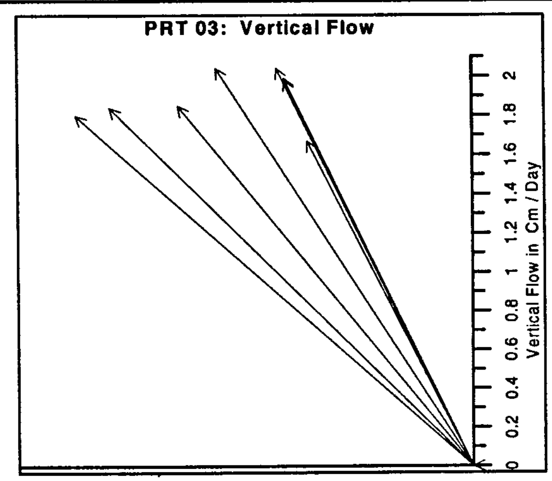
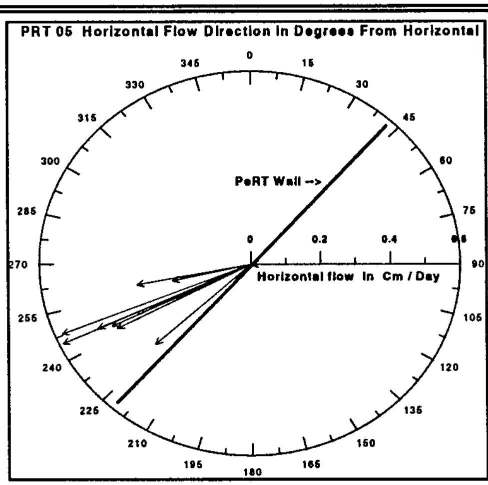


TABLE 4-23
RESULTS FOR FLOW SENSOR AT LOCATION PRT 05

Start Date	Start Time	End Date	End Time	Parameter					
				Vertical flow (cm/day)	Horizontal flow (cm/day)	Total flow (cm/day)	Degrees from Horizontal	Azimuth (° from North)	ERMS
2/22/98	2:33	2/23/98	15:25	-0.24 +/- 0.32	0.37 +/- 0.34	0.44 +/- 0.90	-33.0 +/- 24.6	227.5 +/- 72.8	0.11
3/8/98	0:14	3/9/98	13:13	-0.33 +/- 0.33	0.38 +/- 0.33	0.50 +/- 0.97	-41.0 +/- 26.6	237.2 +/- 75.6	0.11
3/16/98	20:45	3/18/98	9:56	-0.34 +/- 0.34	0.43 +/- 0.35	0.55 +/- 1.03	-38.3 +/- 25.4	242.3 +/- 66.5	0.12
3/25/98	14:30	4/15/98	8:00	-0.38 +/- 0.35	0.44 +/- 0.35	0.58 +/- 1.08	-40.8 +/- 26.1	244.7 +/- 66.3	0.12
4/15/98	8:30	5/14/98	7:00	-0.40 +/- 0.36	0.59 +/- 0.38	0.71 +/- 1.23	-34.1 +/- 23.0	245.1 +/- 49.9	0.12
5/27/98	7:31	6/15/98	11:31	-0.59 +/- 0.38	0.58 +/- 0.38	0.83 +/- 1.36	-45.5 +/- 26.3	247.9 +/- 53.9	0.11
6/18/98	6:18	7/23/98	10:00	-0.53 +/- 0.36	0.48 +/- 0.37	0.72 +/- 1.23	-47.8 +/- 27.2	245.3 +/- 63.3	0.11
7/23/98	10:30	8/11/98	7:30	-0.53 +/- 0.35	0.44 +/- 0.36	0.69 +/- 1.19	-50.3 +/- 27.9	243.9 +/- 68.6	0.11
8/14/98	8:00	9/14/98	8:30	-0.51 +/- 0.35	0.35 +/- 0.35	0.62 +/- 1.11	-55.5 +/- 29.9	244.8 +/- 84.6	0.11
9/17/98	0:00	10/13/98	7:30	-0.49 +/- 0.32	0.23 +/- 0.32	0.54 +/- 0.98	-64.9 +/- 32.2	257.0 +/- 120.9	0.11
10/15/98	0:00	11/16/98	11:30	-0.38 +/- 0.34	0.33 +/- 0.34	0.50 +/- 0.98	-49.0 +/- 29.0	258.9 +/- 91.9	0.11
Average				-0.43 +/- 0.35	0.42 +/- 0.35	0.61 +/- 1.10	-45.5 +/- 27.1	245.0 +/- 74.0	0.11
Standard Deviation				0.11	0.11	0.12	9.5	8.5	0.0



Mandrel JAG

PRT 05 --> X

NOTE: PeRT Wall Oriented at North 410 East

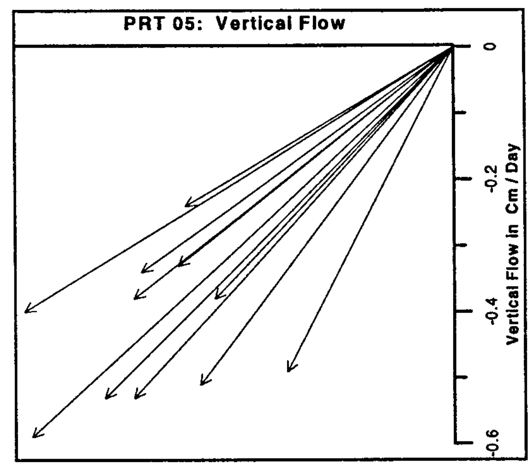
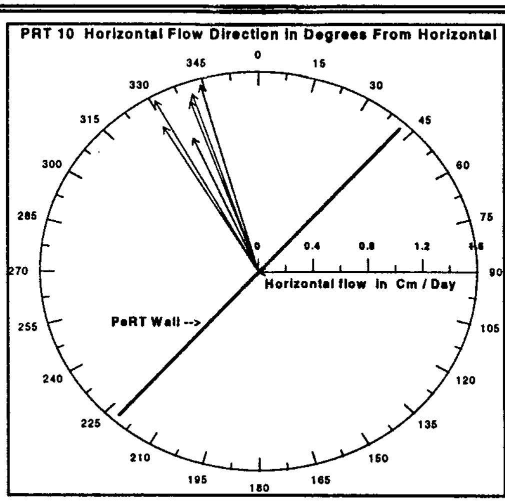


TABLE 4-24
RESULTS FOR FLOW SENSOR AT LOCATION PRT 10

Start Date	Start Time	End Date	End Time	Parameter					
				Vertical flow (cm/day)	Horizontal flow (cm/day)	Total flow (cm/day)	Degrees from Horizontal	Azimuth (° from North)	ERMS
2/22/98	2:33	2/23/98	15:25	-0.68 +/- 0.20	1.50 +/- 0.25	1.65 +/- 1.96	-24.4 +/- 14.1	341.3 +/- 10.2	0.04
3/8/98	0:14	3/9/98	13:13	-0.70 +/- 0.21	1.55 +/- 0.25	1.70 +/- 2.02	-24.3 +/- 14.2	344.2 +/- 10.2	0.04
3/16/98	20:45	3/18/98	9:56	-0.74 +/- 0.21	1.55 +/- 0.25	1.72 +/- 2.04	-25.5 +/- 14.7	342.4 +/- 10.1	0.04
3/25/98	14:30	4/15/98	8:00	-0.83 +/- 0.21	1.60 +/- 0.24	1.80 +/- 2.11	-27.4 +/- 15.4	338.9 +/- 9.6	0.04
4/15/98	8:30	5/14/98	7:00	-0.90 +/- 0.21	1.56 +/- 0.23	1.80 +/- 2.11	-30.0 +/- 16.5	331.1 +/- 9.8	0.04
5/27/98	7:31	6/15/98	11:31	-0.94 +/- 0.21	1.35 +/- 0.22	1.65 +/- 1.95	-34.8 +/- 18.7	329.2 +/- 11.2	0.04
6/18/98	6:18	7/23/98	10:00	-0.85 +/- 0.21	1.27 +/- 0.22	1.53 +/- 1.83	-33.8 +/- 18.4	330.4 +/- 11.3	0.04
7/23/98	10:30	8/11/98	7:30	-0.99 +/- 0.24	1.09 +/- 0.24	1.47 +/- 1.81	-42.2 +/- 22.0	330.9 +/- 14.5	0.04
8/14/98	8:00	9/14/98	8:30	-0.75 +/- 0.21	1.17 +/- 0.22	1.39 +/- 1.69	-32.7 +/- 18.2	336.1 +/- 12.1	0.04
9/17/98	0:00	10/13/98	7:30	-0.83 +/- 0.21	1.39 +/- 0.24	1.62 +/- 1.93	-30.8 +/- 17.0	344.1 +/- 10.8	0.04
10/15/98	0:00	11/16/98	11:30	-0.78 +/- 0.21	1.45 +/- 0.24	1.65 +/- 1.96	-28.3 +/- 15.9	340.0 +/- 10.5	0.04
Average				-0.82 +/- 0.21	1.41 +/- 0.24	1.63 +/- 1.95	-30.4 +/- 16.8	337.1 +/- 10.9	0.04
Standard Deviation				0.099	0.17	0.13	5.4	5.8	8.3E-10



Mandrel JAG

PRT10
V
X

NOTE: PeRT Wall Oriented at North 410 East

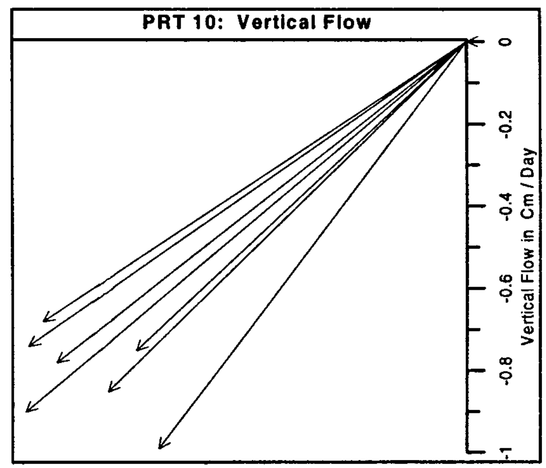
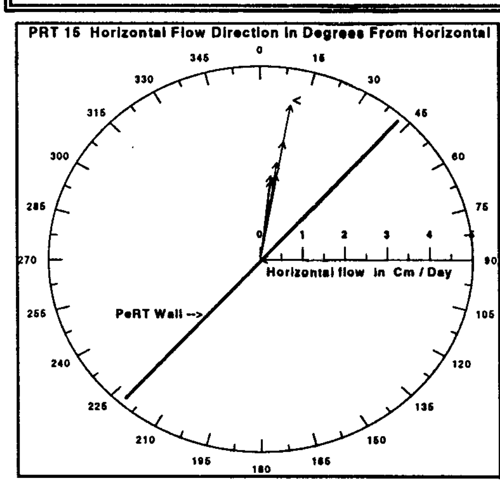
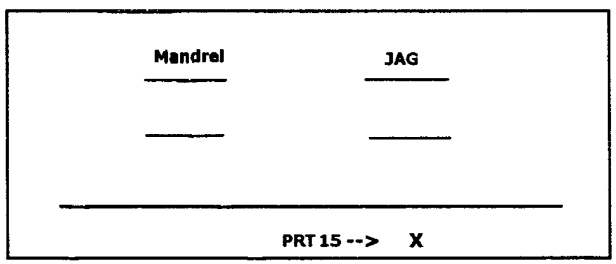


TABLE 4-25
RESULTS FOR FLOW SENSOR AT LOCATION PRT 15

Start Date	Start Time	End Date	End Time	Parameter: Vertical flow (cm/day)	Horizontal flow (cm/day)	Total flow (cm/day)	Degrees from Horizontal	Azimuth (° from North)	ERMS
2/22/98	2:33	2/23/98	15:25	-3.74 +/- 0.59	3.09 +/- 0.58	4.85 +/- 5.68	-50.4 +/- 24.3	10.2 +/- 12.3	0.11
3/8/98	0:14	3/9/98	13:13	-5.26 +/- 0.79	4.18 +/- 0.76	6.72 +/- 7.81	-51.5 +/- 24.6	10.8 +/- 10.8	0.14
3/16/98	20:45	3/18/98	9:56	-5.08 +/- 0.76	4.05 +/- 0.73	6.50 +/- 7.55	-51.4 +/- 24.6	10.2 +/- 11.6	0.13
3/25/98	14:30	4/15/98	8:00	-4.66 +/- 0.68	3.55 +/- 0.66	5.86 +/- 6.80	-52.7 +/- 25.0	10.5 +/- 12.0	0.12
4/15/98	8:30	5/14/98	7:00	-3.44 +/- 0.49	2.54 +/- 0.49	4.28 +/- 4.96	-53.6 +/- 25.2	8.8 +/- 12.6	0.10
5/27/98	7:31	6/15/98	11:31	-3.37 +/- 0.45	2.24 +/- 0.46	4.05 +/- 4.68	-56.4 +/- 26.0	9.7 +/- 13.3	0.10
6/18/98	6:18	7/23/98	10:00	-3.11 +/- 0.42	2.07 +/- 0.43	3.74 +/- 4.33	-56.4 +/- 26.0	7.2 +/- 13.5	0.10
7/23/98	10:30	8/11/98	7:30	-3.08 +/- 0.42	2.05 +/- 0.42	3.70 +/- 4.28	-56.4 +/- 26.0	7.0 +/- 13.5	0.09
8/14/98	8:00	9/14/98	8:30	-3.17 +/- 0.43	2.18 +/- 0.44	3.85 +/- 4.45	-55.5 +/- 25.7	6.6 +/- 13.1	0.09
9/17/98	0:00	10/13/98	7:30	-4.91 +/- 0.67	3.53 +/- 0.64	6.05 +/- 6.97	-54.3 +/- 25.4	8.4 +/- 11.7	0.12
10/15/98	0:00	11/16/98	11:30	-4.76 +/- 0.66	3.53 +/- 0.63	5.93 +/- 6.83	-53.4 +/- 25.1	7.6 +/- 11.6	0.12
Average				-4.05 +/- 0.58	3.00 +/- 0.57	5.05 +/- 5.85	-53.8 +/- 25.3	8.8 +/- 12.4	0.11
Standard Deviation				0.876	0.81	1.18	2.2	1.6	0.02





NOTE: PeRT Wall Oriented at North 410 East

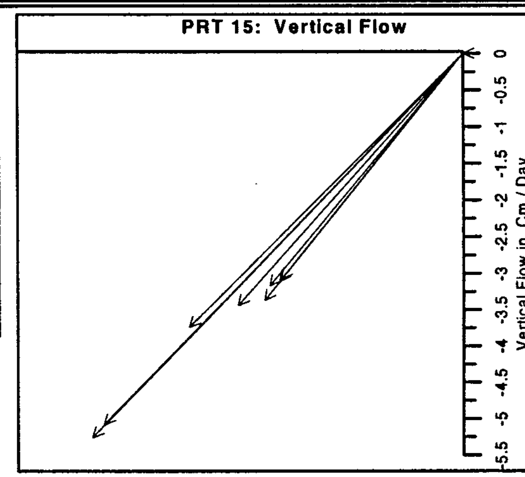
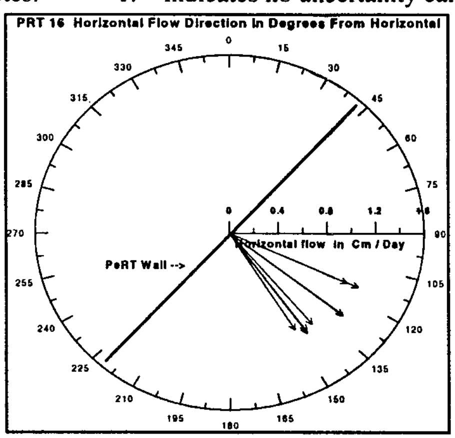
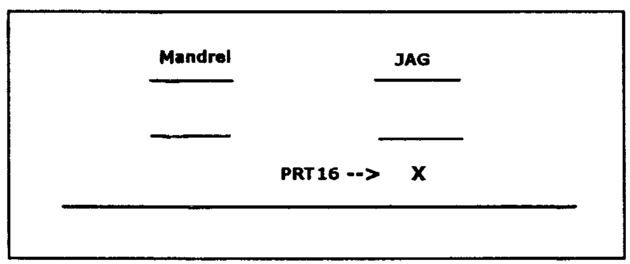


TABLE 4-26
RESULTS FOR FLOW SENSOR AT LOCATION PRT 16

Start Date	Start Time	End Date	End Time	Vertical flow (cm/day)	Horizontal flow (cm/day)	Total flow (cm/day)	Degrees from Horizontal	Azimuth (° from North)	ERMS
				Parameter					
2/22/98	2:33	2/23/98	15:25	6.67 +/- *	1.06 +/- *	6.75 +/- *	81.0 +/- *	114.9 +/- *	0.50
3/8/98	0:14	3/9/98	13:13	7.67 +/- *	1.38 +/- *	7.79 +/- *	79.8 +/- *	120.8 +/- *	0.49
3/16/98	20:45	3/18/98	9:56	7.69 +/- *	1.33 +/- *	7.80 +/- *	80.2 +/- *	123.1 +/- *	0.49
3/25/98	14:30	4/15/98	8:00	7.45 +/- *	1.18 +/- *	7.54 +/- *	81.0 +/- *	128.5 +/- *	0.48
4/15/98	8:30	5/14/98	7:00	7.45 +/- *	1.08 +/- *	7.53 +/- *	81.8 +/- *	144.5 +/- *	0.48
5/27/98	7:31	6/15/98	11:31	6.68 +/- *	1.02 +/- *	6.76 +/- *	81.3 +/- *	148.6 +/- *	0.47
6/18/98	6:18	7/23/98	10:00	7.31 +/- *	1.10 +/- *	7.39 +/- *	81.4 +/- *	144.9 +/- *	0.49
7/23/98	10:30	8/11/98	7:30	7.39 +/- *	1.06 +/- *	7.47 +/- *	81.8 +/- *	140.5 +/- *	0.49
8/14/98	8:00	9/14/98	8:30	7.52 +/- *	1.07 +/- *	7.60 +/- *	81.9 +/- *	137.7 +/- *	0.49
9/17/98	0:00	10/13/98	7:30	7.29 +/- *	1.16 +/- *	7.38 +/- *	81.0 +/- *	114.7 +/- *	0.50
10/15/98	0:00	11/16/98	11:30	7.17 +/- *	1.13 +/- *	7.26 +/- *	81.0 +/- *	121.7 +/- *	0.50
Average				7.30 +/- *	1.14 +/- *	7.39 +/- *	81.1 +/- *	130.9 +/- *	0.49
Standard Deviation				0.345	0.12	0.35	0.7	12.7	0.01

Notes: 1: * indicates no uncertainty calculated because ERMS value is above 0.30.





NOTE: PeRT Wall Oriented at North 410 East

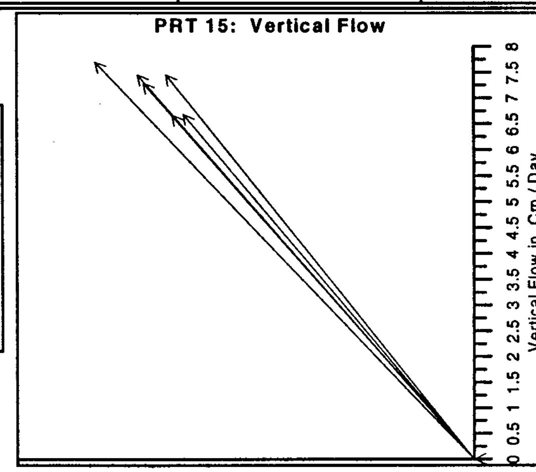
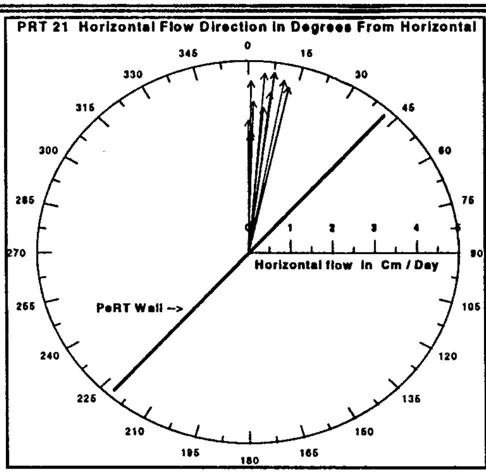
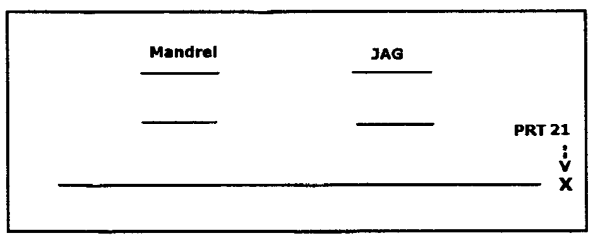


TABLE 4-26: RESULTS FOR FLOW SENSOR AT LOCATION PRT 16

TABLE 4-27
RESULTS FOR FLOW SENSOR AT LOCATION PRT 21

Start Date	Start Time	End Date	End Time	Parameter: Vertical flow (cm/day)	Horizontal flow (cm/day)	Total flow (cm/day)	Degrees from Horizontal	Azimuth (° from North)	ERMS
2/22/98	2:33	2/23/98	15:25	-9.90 +/- 1.84	3.81 +/- 1.56	10.61 +/- 12.91	-69.0 +/- 29.9	5.5 +/- 25.1	0.20
3/8/98	0:14	3/9/98	13:13	-10.50 +/- 1.96	4.43 +/- 1.63	11.40 +/- 13.86	-67.1 +/- 29.6	12.5 +/- 22.5	0.20
3/16/98	20:45	3/18/98	9:56	-10.81 +/- 2.02	4.58 +/- 1.66	11.74 +/- 14.27	-67.0 +/- 29.6	10.8 +/- 22.0	0.20
3/25/98	14:30	4/15/98	8:00	-11.37 +/- 2.12	4.75 +/- 1.69	12.32 +/- 14.95	-67.3 +/- 29.6	7.6 +/- 21.4	0.20
4/15/98	8:30	5/14/98	7:00	-11.45 +/- 2.08	4.49 +/- 1.66	12.30 +/- 14.86	-68.6 +/- 29.9	0.9 +/- 22.2	0.20
5/27/98	7:31	6/15/98	11:31	-11.85 +/- 2.09	3.96 +/- 1.62	12.49 +/- 15.02	-71.5 +/- 30.4	1.8 +/- 26.7	0.19
6/18/98	6:18	7/23/98	10:00	-9.93 +/- 1.76	3.47 +/- 1.48	10.52 +/- 12.69	-70.7 +/- 30.2	0.1 +/- 27.3	0.20
7/23/98	10:30	8/11/98	7:30	-9.37 +/- 1.66	3.19 +/- 1.43	9.90 +/- 11.96	-71.2 +/- 30.3	1.3 +/- 29.6	0.20
8/14/98	8:00	9/14/98	8:30	-9.17 +/- 1.63	3.11 +/- 1.41	9.68 +/- 11.71	-71.3 +/- 30.3	0.9 +/- 30.2	0.20
9/17/98	0:00	10/13/98	7:30	-10.65 +/- 1.92	4.22 +/- 1.58	11.46 +/- 13.84	-68.4 +/- 29.8	7.2 +/- 22.9	0.19
10/15/98	0:00	11/16/98	11:30	-11.28 +/- 2.06	4.70 +/- 1.66	12.22 +/- 14.78	-67.4 +/- 29.6	4.8 +/- 21.4	0.19
Average				-10.57 +/- 1.92	4.06 +/- 1.58	11.33 +/- 13.71	-69.0 +/- 29.9	4.9 +/- 24.7	0.20
Standard Deviation				0.89	0.6	1.01	1.8	4.3	0.0047





NOTE: PeRT Wall Oriented at North 410 East

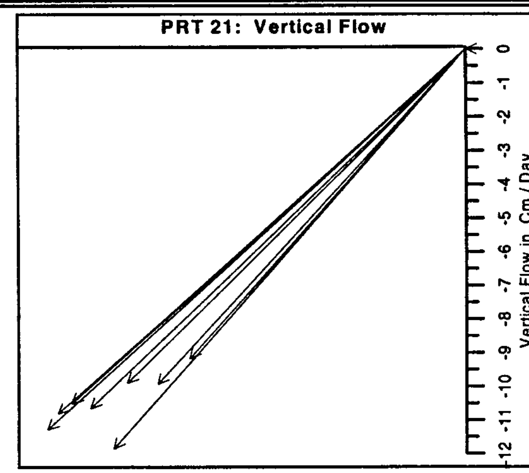


TABLE 4-28
GROUNDWATER FLOW DIRECTIONS

	INTERMEDIATE WELLS										
	PeRT Wall Segments										
Date	I01 / I02	Between*	I09 / I03	Between*	I12 / I11	Between*	I14 / I13	Between*	I18 / I15	Between*	I20 / I19
2/19/98	SE	NE	NE to N	NE to N	NE to N	NE to N	N	N to NW	NW to N	N	N
3/16/98	SE	NE	N to NE	NE	N	NNW	NW	W	NW to N	N	N
4/13/98	SE	NE	N to NE	NE to N	N	NNW	NW	WNW	W to N	NE	NE
5/18/98	SE	NNW	NW	NW	NE to NW	NE to N	NW	W	NW	N	N
6/15/98	SE	NW	NNW	NNW	NNW	NE to NW	NW	W to NW	NW	N to NW	NNW
7/13/98	SE	NE	N	N	N	N to NE	NW	NW to W	NW	N to NE	SE
8/10/98	SE	NW	NW	NNW	NNW	NNW to N	NW	W	NW	N to NNW	NNW
9/14/98	SE	ENE to NE	N to NE	NNW	NNW	NNW to N	NW	W	NW	NNW to N	NW
10/12/98	SE	NNW	NNW	N	N	NE	NW to N	WNW	NW	N to NNW	NNW
11/16/98	SE	NNW	NNW	NNW	NNW	N to NE	NW	W	NW	NNW	NW

	DEEP WELLS										
	PeRT Wall Segments										
Date	D01 / D02	Between*	D09 / D03	Between*	D12 / D11	Between*	D14 / D13	Between*	D18 / D15	Between*	D20 / D19
2/19/98	SE	W	NW	NNW	NW	NW to NE	SE	WNW	NW	NNW	NW
3/16/98	NW	NNW	NNW	NW	NW	NW to NE	SE	NW to W	NW	NNW	NW
4/13/98	NW	N	NNW	NW	NW	NW to NE	SE	NW to W	NW	NW	NW
5/18/98	NW	NW	NW	NNW	NNW	NW to NE	SE	NW to W	NW	NNW	NW
6/15/98	NW	NNW	NNW	NW	NW	NW to NE	SE	NW to NNE	N	NW	NW
7/13/98	NW	NW	NW	NW	NW	NW to NE	SE	W to SW	NW	NW to N	NW
8/10/98	NW	NW	NW to W	W to NW	NW	NW	NW	NNW	NW	NNW	NNW
9/14/98	NW	NNW	NNW	NNW	NW	NW to NE	NW & NE	W	NW	NNW	NNW
10/12/98	NW	NW	N to NE	NW	NNW	NW to NE	NW & NE	W to NW	NW	NW	NW
11/16/98	NW	NNW	N to NE	NW	NW	NW to NE	SE	W to SW	NW to N	NNW	NNW

Notes:
PeRT Wall trends SW to NE
Flow perpendicular to wall would have NW flow direction.
A flow direction of SE would be reverse of anticipated flow direction.

Between* Between Well Sets listed to the left and right

TABLE 4-29
GROUNDWATER ELEVATIONS AND HORIZONTAL HEAD DIFFERENCES BY WELL SETS, IN INTERMEDIATE AND DEEP WELLS AT THE PeRT WALL, BY MEASUREMENT DATE

INTERMEDIATE WELLS

MONITORING WELL IDENTIFICATION	NORTHING	EASTING	Well Pair Separation			2/19/98		03/16/98		04/13/98		05/18/98		06/15/98		07/13/98		08/10/98		09/14/98		10/12/98		11/16/98	
			x	y	dist	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H
HGRK-PRTMWI01	1511852	790762	3.84	-3.48		4.87		4.79		4.23		3.54		2.91		3.02		2.73		3.89		4.95		4.31	
HGRK-PRTMWI02	1511856	790758	14.75	12.10	5.181	4.91	-0.04	4.81	-0.02	4.25	-0.02	3.56	-0.02	2.92	-0.01	3.04	-0.02	2.75	-0.02	3.91	-0.02	4.97	-0.02	4.32	-0.01
HGRK-PRTMWI03	1511861	790770	2.21	-4.67		4.89		4.81		4.25		3.56		2.93		3.03		2.80		3.89		4.97		4.32	
HGRK-PRTMWI05	1511866	790768	4.87	21.81	5.165	4.88	0.01	4.8	0.01	4.23	0.02	3.54	0.02	2.91	0.02	3.02	0.01	2.73	0.07	3.89	0	4.94	0.03	4.30	0.02
HGRK-PRTMWI11	1511875	790783	3.88	-3.63		4.85		4.77		4.21		3.53		2.90		3.01		2.74		3.88		4.92		4.29	
HGRK-PRTMWI12	1511879	790779	15.06	13.19	5.315	4.85	0.00	4.76	0.01	4.2	0.01	3.53	0	2.88	0.02	3.00	0.01	2.70	0.04	3.85	0.03	4.91	0.01	4.27	0.02
HGRK-PRTMWI13	1511889	790796	2.71	-2.81														2.70		3.86		4.90		4.27	
HGRK-PRTMWI14	1511892	790794	7.34	7.92	3.907	4.80		4.72		4.16		3.48		2.83		2.95		2.66		3.81	0.05	4.86	0.04	4.22	0.05
HGRK-PRTMWI15	1511898	790804	1.61	-3.96		4.87		4.78		4.23		3.55		2.91		3.02		2.73		3.88		4.92		4.28	
HGRK-PRTMWI16	1511902	790803	2.59	15.67	4.273	4.83	0.04	4.74	0.04	4.18	0.05	3.51	0.04	2.86	0.05	2.99	0.03	2.69	0.04	3.84	0.04	4.89	0.03	4.25	0.03
HGRK-PRTMWI19	1511912	790817	2.94	-3.01		4.83		4.73		4.15		3.51		2.87		2.96		2.69		3.84		4.87		4.25	
HGRK-PRTMWI20	1511915	790814	8.67	9.07	4.213	4.80	0.03	4.7	0.03	4.15	0	3.47	0.04	2.84	0.03	2.97	-0.01	2.66	0.03	3.81	0.03	4.84	0.03	4.21	0.04
				Average:			0.01		0.01		0.01		0.02		0.02		0.00		0.03		0.02		0.02		0.03
Downgradient of wall																									
HGRK-PRTMWI07	1511868	790765	2.77	-2.41		4.88		4.78		4.25		3.52		2.89		3.02		2.74		3.88		4.94		4.29	
HGRK-PRTMWI09	1511870	790762	7.69	5.80	3.673	4.85	0.03	4.76	0.02	4.20	0.05	3.50	0.02	2.87	0.02	2.99	0.03	2.70	0.04	3.85	0.03	4.91	0.03	4.27	0.02
HGRK-PRTMWI17	1511904	790799	3.39	-3.02		4.82		4.74		4.18		3.50		2.87		2.99		2.69		3.85		4.88		4.24	
HGRK-PRTMWI18	1511907	790796	11.48	9.14	4.541	4.79	0.03	4.70	0.04	4.16	0.02	3.46	0.04	2.83	0.04	2.94	0.05	2.65	0.04	3.80	0.05	4.85	0.03	4.21	0.03

DEEP WELLS

MONITORING WELL IDENTIFICATION	NORTHING	EASTING	Well Pair Separation			02/19/98		03/16/98		04/13/98		05/18/98		06/15/98		07/13/98		08/10/98		09/14/98		10/12/98		11/16/98	
			x	y	dist	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H	GW elev	del H
HGRK-PRTMWD01	1511851	790761	3.70	-2.92		4.82		4.79		4.22		3.55		2.92		3.04		2.73		3.91		4.96		4.30	
HGRK-PRTMWD02	1511854	790757	13.68	8.53	4.713	4.83	-0.01	4.78	0.01	4.22	0.00	3.54	0.01	2.90	0.02	3.02	0.02	2.72	0.01	3.90	0.01	4.95	0.01	4.29	0.01
HGRK-PRTMWD03	1511860	790769	1.85	-4.85		4.89		4.79		4.23		3.56		2.91		3.03		2.74		3.92		4.96		4.29	
HGRK-PRTMWD05	1511864	790767	3.43	23.54	5.193	4.84	0.05	4.74	0.05	4.19	0.04	3.53	0.03	2.88	0.03	3.01	0.02	2.73	0.01	3.88	0.04	4.93	0.03	4.26	0.03
HGRK-PRTMWD11	1511873	790782	4.22	-3.42		4.86		4.78		4.22		3.54		2.92		3.03		2.80		3.90		4.94		4.29	
HGRK-PRTMWD12	1511877	790778	17.85	11.69	5.435	4.82	0.04	4.74	0.04	4.18	0.04	3.51	0.03	2.89	0.03	2.99	0.04	2.71	0.09	3.85	0.05	4.90	0.04	4.25	0.04
HGRK-PRTMWD13	1511888	790795	3.60	-3.07		4.79		4.70		4.15		3.47		2.84		2.95		2.73		3.82		4.86		4.22	
HGRK-PRTMWD14	1511891	790792	12.94	9.41	4.728	4.82	-0.03	4.71	-0.01	4.16	-0.01	3.48	-0.01	2.89	-0.05	2.97	-0.02	2.68	0.05	3.82	0.00	4.86	0.00	4.23	-0.01
HGRK-PRTMWD15	1511897	790803	1.70	-3.93		4.85		4.75		4.21		3.53		2.88		3.00		2.73		3.86		4.90		4.27	
HGRK-PRTMWD16	1511901	790801	2.89	15.42	4.279	4.83	0.02	4.72	0.03	4.17	0.04	3.51	0.02	2.86	0.02	2.99	0.01	2.71	0.02	3.85	0.01	4.87	0.03	4.23	0.04
HGRK-PRTMWD19	1511911	790816	3.36	-2.69		4.83		4.73		4.18		3.51		2.87		3.05		2.69		3.85		4.88		4.24	
HGRK-PRTMWD20	1511913	790812	11.29	7.24	4.304	4.79	0.04	4.71	0.02	4.15	0.03	3.47	0.04	2.84	0.03	2.87	0.18	2.66	0.03	3.82	0.03	4.83	0.05	4.21	0.03
				Average:			0.02		0.02		0.02		0.02		0.01		0.04		0.03		0.02		0.03		0.02
Downgradient of wall																									
HGRK-PRTMWD07	1511866	790764	2.49	-3.63		4.84		4.74		4.18		3.52		2.88		3.00		2.71		3.87		4.94		4.27	
HGRK-PRTMWD09	1511870	790761	6.20	13.15	4.398	4.82	0.02	4.73	0.01	4.18	0.00	3.50	0.02	2.87	0.01	2.98	0.02	2.69	0.02	3.86	0.01	4.91	0.03	4.25	0.02
HGRK-PRTMWD17	1511903	790797	2.66	-2.94		4.82		4.72		4.10		3.48		2.86		2.98		2.68		3.84		4.87		4.23	
HGRK-PRTMWD18	1511906	790795	7.05	8.66	3.963	4.81	0.01	4.70	0.02	4.14	-0.04	3.46	0.02	2.83	0.03	2.97	0.01	2.64	0.04	3.82	0.02	4.86	0.01	4.21	0.02

TABLE 4-30
GROUNDWATER FLOW DIRECTIONS

Hangar K Area DEEP Wells

Date	West (Downgradient)	Middle (PeRT Wall Area	East (Upgradient)
8/7/97	WNW	WNW	N & S
2/2/98	WNW	NW	NE
2/19/98	WNW	NNW	NNE
3/16/98	NW	NNW	N to NNE
4/13/98	NW	NNW	NNE
5/18/98		NW	NNW
6/15/98	NW	NW	NNW
7/13/98	NW	NW	N
8/10/98	WNW	NW	N
9/14/98	NW	NW	NNE
10/12/98	NNW	NW	NE
11/16/98	NW	SE & NE	NNW to NNE

Hangar K Area Below PeRT Wall Wells

Date	West (Downgradient)	Middle (PeRT Wall Area	East (Upgradient)
8/7/97	WNW	W	W
2/2/98	WNW	NW	NW
2/19/98	WNW	NW	W
3/16/98	WNW	NW	W
4/13/98	W	NNW	WNW
5/18/98			WNW
6/15/98	NW	NW	NW
7/13/98	NW	NW	NW
8/10/98	NW	NW	NW
9/14/98	WNW	WNW	W
10/12/98	WNW	WNW	WNW
11/16/98	WNW	WNW	WNW

TABLE 4-31
HORIZONTAL SLOPE AND VELOCITY FOR PeRT WALL MONITORING WELL SETS

INTERMEDIATE WELLS

Horizontal Slope (Slope in Ft/Ft)

MONITORING WELL IDENTIFICATION	2/19/98	03/16/98	04/13/98	05/18/98	06/15/98	07/13/98	08/10/98	09/14/98	10/12/98	11/16/98	avg
HGRK-PRTMWI01	-0.00772	-0.00386	-0.00386	-0.00386	-0.00965	-0.00386	-0.00386	-0.00386	-0.00386	-0.00193	0.00463
HGRK-PRTMWI02											
HGRK-PRTMWI03	0.00194	0.00194	0.00387	0.00387	0.01936	0.00194	0.01355	0.00000	0.00581	0.00387	0.00561
HGRK-PRTMWI05											
HGRK-PRTMWI11	0.00000	0.00188	0.00188	0.00188	0.01881	0.00188	0.00753	0.00564	0.00188	0.00376	0.00452
HGRK-PRTMWI12											
HGRK-PRTMWI13	- - -	- - -	- - -	- - -	- - -	- - -	- - -	0.01280	0.01024	0.01280	0.01195
HGRK-PRTMWI14											
HGRK-PRTMWI15	0.00936	0.00936	0.01170	0.01170	0.05850	0.00702	0.00936	0.00936	0.00702	0.00702	0.01404
HGRK-PRTMWI16											
HGRK-PRTMWI19	0.00712	0.00712	0.00000	0.00000	0.03561	-0.00237	0.00712	0.00712	0.00712	0.00950	0.00831
HGRK-PRTMWI20											
Average:	**0.00214**	**0.00329**	**0.00272**	**0.00272**	**0.02453**	**0.00092**	**0.00674**	**0.00518**	**0.00470**	**0.00584**	**0.00818**
Downgradient of wall											
HGRK-PRTMWI07	0.00817	0.00545	0.01361	0.01361	0.02723	0.00817	0.01089	0.00817	0.00817	0.00545	0.01089
HGRK-PRTMWI09											
HGRK-PRTMWI17	0.00661	0.00881	0.00440	0.00440	0.04404	0.01101	0.00881	0.01101	0.00661	0.00661	0.01123
HGRK-PRTMWI18											

Horizontal Velocity (Velocity, in Feet/Day)

MONITORING WELL IDENTIFICATION	2/19/98	03/16/98	04/13/98	05/18/98	06/15/98	07/13/98	08/10/98	09/14/98	10/12/98	11/16/98
HGRK-PRTMWI01	-0.03860	-0.01930	-0.01930	-0.01930	-0.00193	-0.01930	-0.01930	-0.01930	-0.01930	-0.00965
HGRK-PRTMWI02										
HGRK-PRTMWI03	0.00968	0.00968	0.01936	0.01936	0.00387	0.00968	0.06777	0.00000	0.02904	0.01936
HGRK-PRTMWI05										
HGRK-PRTMWI11	0.00000	0.00941	0.00941	0.00941	0.00376	0.00941	0.03763	0.02822	0.00941	0.01881
HGRK-PRTMWI12										
HGRK-PRTMWI13	- - -	- - -	- - -	- - -	- - -	- - -	- - -	0.06399	0.05119	0.06399
HGRK-PRTMWI14										
HGRK-PRTMWI15	0.04680	0.04680	0.05850	0.05850	0.01170	0.03510	0.04680	0.04680	0.03510	0.03510
HGRK-PRTMWI16										
HGRK-PRTMWI19	0.03561	0.03561	0.00000	0.00000	0.00712	-0.01187	0.03561	0.03561	0.03561	0.04748
HGRK-PRTMWI20										
Average:	**0.02614**	**0.02416**	**0.02131**	**0.02131**	**0.02839**	**0.01707**	**0.04142**	**0.03232**	**0.02994**	**0.03240**
Downgradient of wall										
HGRK-PRTMWI07	0.04084	0.02723	0.06807	0.06807	0.00545	0.04084	0.05446	0.04084	0.04084	0.02723
HGRK-PRTMWI09										
HGRK-PRTMWI17	0.03303	0.04404	0.02202	0.02202	0.00881	0.05505	0.04404	0.05505	0.03303	0.03303
HGRK-PRTMWI18										

DEEP WELLS

Horizontal Slope (Slope in Ft/Ft)

MONITORING WELL IDENTIFICATION	2/19/98	03/16/98	04/13/98	05/18/98	06/15/98	07/13/98	08/10/98	09/14/98	10/12/98	11/16/98	avg
HGRK-PRTMWD01	-0.00212	0.00212	0.00000	0.00212	0.00424	0.00424	0.00212	0.00212	0.00212	0.00212	0.00233
HGRK-PRTMWD02											
HGRK-PRTMWD03	0.00963	0.00963	0.00770	0.00578	0.00578	0.00385	0.00193	0.00770	0.00578	0.00578	0.00635
HGRK-PRTMWD05											
HGRK-PRTMWD11	0.00736	0.00736	0.00736	0.00552	0.00552	0.00736	0.01656	0.00920	0.00736	0.00736	0.00810
HGRK-PRTMWD12											
HGRK-PRTMWD13	-0.00635	-0.00212	-0.00212	-0.00212	-0.01058	-0.00423	0.05288	0.00000	0.00000	-0.00212	0.00825
HGRK-PRTMWD14											
HGRK-PRTMWD15	0.00467	0.00701	0.00935	0.00467	0.00467	0.00234	0.02337	0.00234	0.00701	0.00935	0.00748
HGRK-PRTMWD16											
HGRK-PRTMWD19	0.00929	0.00465	0.00697	0.00929	0.00697	0.04182	0.03485	0.00697	0.01162	0.00697	0.01394
HGRK-PRTMWD20											
Average:	**0.00375**	**0.00478**	**0.00488**	**0.00421**	**0.00277**	**0.00923**	**0.02195**	**0.00472**	**0.00565**	**0.00491**	**0.00774**
Downgradient of wall											
HGRK-PRTMWD07	0.00456	0.00227	0.00000	0.00455	0.00227	0.00455	0.00455	0.00227	0.00682	0.00455	0.00364
HGRK-PRTMWD09											
HGRK-PRTMWD17	0.00252	0.00505	-0.01009	0.00505	0.00757	0.00252	0.01009	0.00505	0.00252	0.00505	0.00555
HGRK-PRTMWD18											

Horizontal Velocity (Velocity, in Feet/Day)

MONITORING WELL IDENTIFICATION	2/19/98	03/16/98	04/13/98	05/18/98	06/15/98	07/13/98	08/10/98	09/14/98	10/12/98	11/16/98
HGRK-PRTMWD01	-0.01061	0.01061	0.00000	0.01061	0.02122	0.02122	0.01061	0.01061	0.01061	0.01061
HGRK-PRTMWD02										
HGRK-PRTMWD03	0.04814	0.04814	0.03851	0.02888	0.02888	0.01926	0.00963	0.03851	0.02888	0.02888
HGRK-PRTMWD05										
HGRK-PRTMWD11	0.03680	0.03680	0.03680	0.02760	0.02760	0.03680	0.08280	0.04600	0.03680	0.03680
HGRK-PRTMWD12										
HGRK-PRTMWD13	-0.03173	-0.01058	-0.01058	-0.01058	-0.05288	-0.02115	0.01058	0.00000	0.00000	-0.01058
HGRK-PRTMWD14										
HGRK-PRTMWD15	0.02337	0.03506	0.04674	0.02337	0.02337	0.01169	0.00467	0.01169	0.03506	0.04674
HGRK-PRTMWD16										
HGRK-PRTMWD19	0.04647	0.02323	0.03485	0.04647	0.03485	0.20910	0.00697	0.03485	0.05808	0.03485
HGRK-PRTMWD20										
Average:	**0.03285**	**0.02740**	**0.02791**	**0.02458**	**0.03147**	**0.05320**	**0.03569**	**0.02361**	**0.02824**	**0.02808**
Downgradient of wall										
HGRK-PRTMWD07	0.02274	0.01137	0.00000	0.02274	0.01137	0.02274	0.02274	0.01137	0.03411	0.02274
HGRK-PRTMWD09										
HGRK-PRTMWD17	0.01262	0.02523	-0.05047	0.02523	0.03785	0.01262	0.05047	0.02523	0.01262	0.02523
HGRK-PRTMWD18										

TABLE 4-32
DEEP GROUNDWATER HORIZONTAL SLOPE AND VELOCITY

	west				wall area			
Date	**Rise**	**Run**	**Gradient**	**Velocity**	**Rise**	**Run**	**Gradient**	**Velocity**
8/7/97	0.35	300	0.00117	0.00583	0.05	110	0.00045	0.00227
2/2/98	0.55	350	0.00157	0.00786	0.1	100	0.00100	0.00500
2/19/98	0.35	205	0.00171	0.00854	0.1	80	0.00125	0.00625
3/16/98	0.45	302	0.00149	0.00745	0.05	55	0.00091	0.00455
4/13/98	0.4	310	0.00129	0.00645	0.05	51	0.00098	0.00490
5/18/98	- -	- -	- -	- -	- -	- -	- -	- -
6/15/98	0.35	270	0.00130	0.00648	0.1	78	0.00128	0.00641
7/13/98	0.3	208	0.00144	0.00721	0.05	60	0.00083	0.00417
8/10/98	0.3	275	0.00109	0.00545	0.07	120	0.00058	0.00292
9/14/98	0.35	230	0.00152	0.00761	0.05	50	0.00100	0.00500
10/12/98	0.35	205	0.00171	0.00854	0.05	57	0.00088	0.00439
11/16/98	0.4	265	0.00151	0.00755			- -	
		Average:	0.00144	**0.00718**		Average:	0.00092	**0.00458**

TABLE 4-33
SUMMARY OF FLOW SENSOR FLOW DATA

		Vertical flow (Ft/day)	Horizontal flow (Ft/day)	Total flow (Ft/day)	Degrees from Horizontal	Azimuth (° from North)	ERMS
PRT 03	Average	0.063 +/- *	0.025 +/- *	0.068 +/- *	68.251 +/- *	21.155 +/- *	0.342
PRT 05	Average	-0.014 +/- 0.35	0.014 +/- 0.35	0.020 +/- 1.10	-45.479 +/- 27.11	244.964 +/- 74.03	0.113
PRT 10	Average	-0.027 +/- 0.21	0.046 +/- 0.24	0.054 +/- 1.95	-30.389 +/- 16.82	337.145 +/- 10.94	0.040
PRT 15	Average	-0.133 +/- 0.21	0.098 +/- 0.24	0.166 +/- 1.95	-30.389 +/- 16.82	337.145 +/- 10.94	0.040
PRT 16	Average	0.239 +/- *	0.037 +/- *	0.242 +/- *	81.110 +/- *	130.900 +/- *	0.489
PRT 21	Average	-0.347 +/- 1.92	0.133 +/- 1.58	0.372 +/- 13.71	-69.047 +/- 29.94	4.850 +/- 24.66	0.197
Average:		0.137	0.059	0.154	54.11	179.36	

TABLE 4-34
ESTIMATED DISSOLVED IRON GENERATED BY CORROSION OF FE^{+0} AT CAPE CANAVERAL PERT WALL

Corrosion Agent	Fe Generated(mg/L)
Dissolved Oxygen	0.5
Water	0.9
C/T DCE	66
Vinyl Chloride	51
TOTAL	118

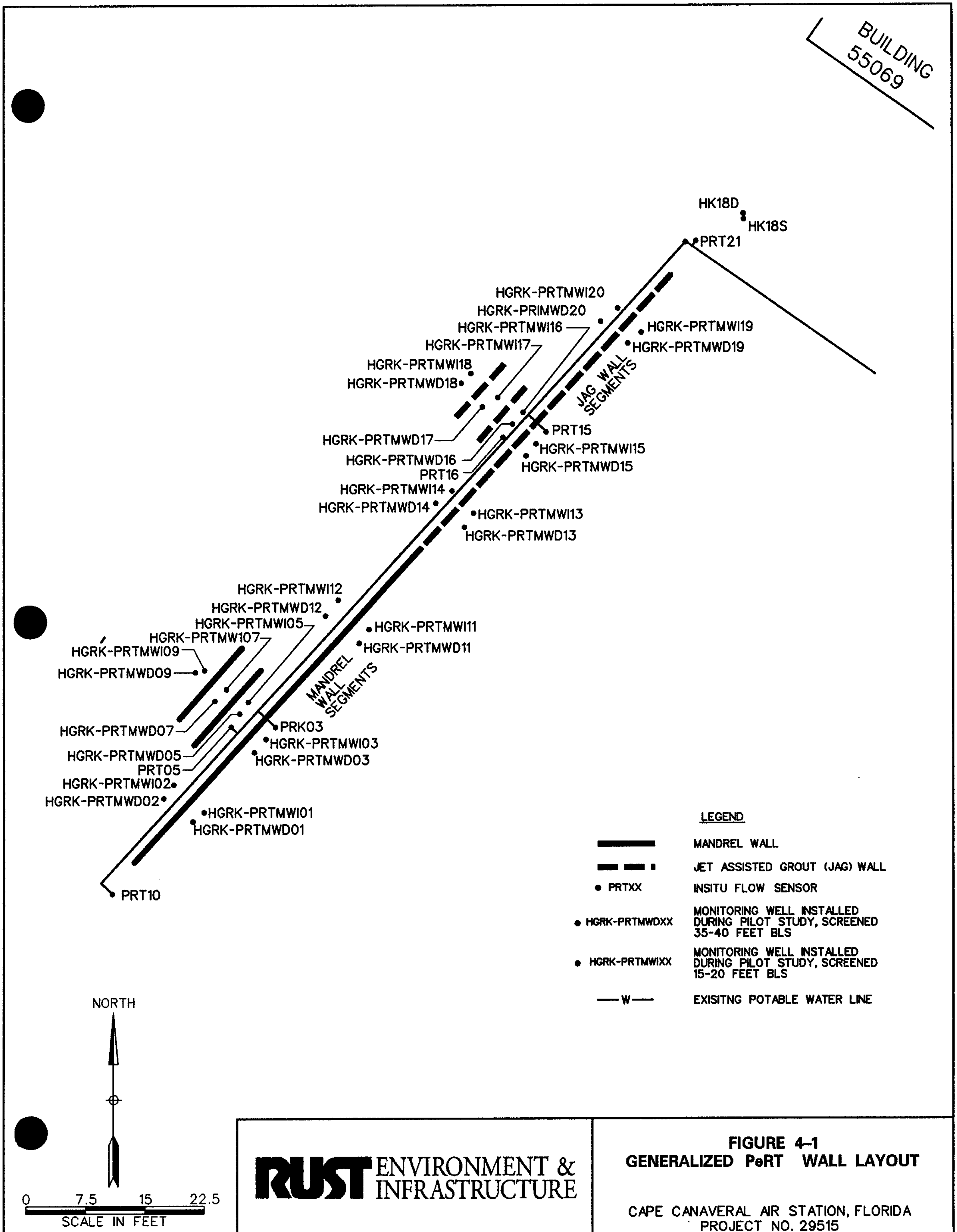
TABLE 4-35
CHANGES IN SELECTED INORGANIC FIELD CHEMISTRY PARAMETERS ACROSS THE MAIN PeRT WALL
NOVEMBER 1998

	pH	ALKALINITY mg/L CaCO3	ORP mV
Deep, Upgradient[a]	7.57	403	-130
Deep, Downgradient[b]	7.69	350	-171
Intermed, Upgradient[a]	7.62	166	-106
Intermed, Downgradient[b]	9.21	94	-136

[a]Upgradient = average of wells 01, 03, 11, 13, 15, and 19

[b]Downgradient = average of wells 02, 05, 12, 14, 16, and 20

ORP = oxidation reduction potential

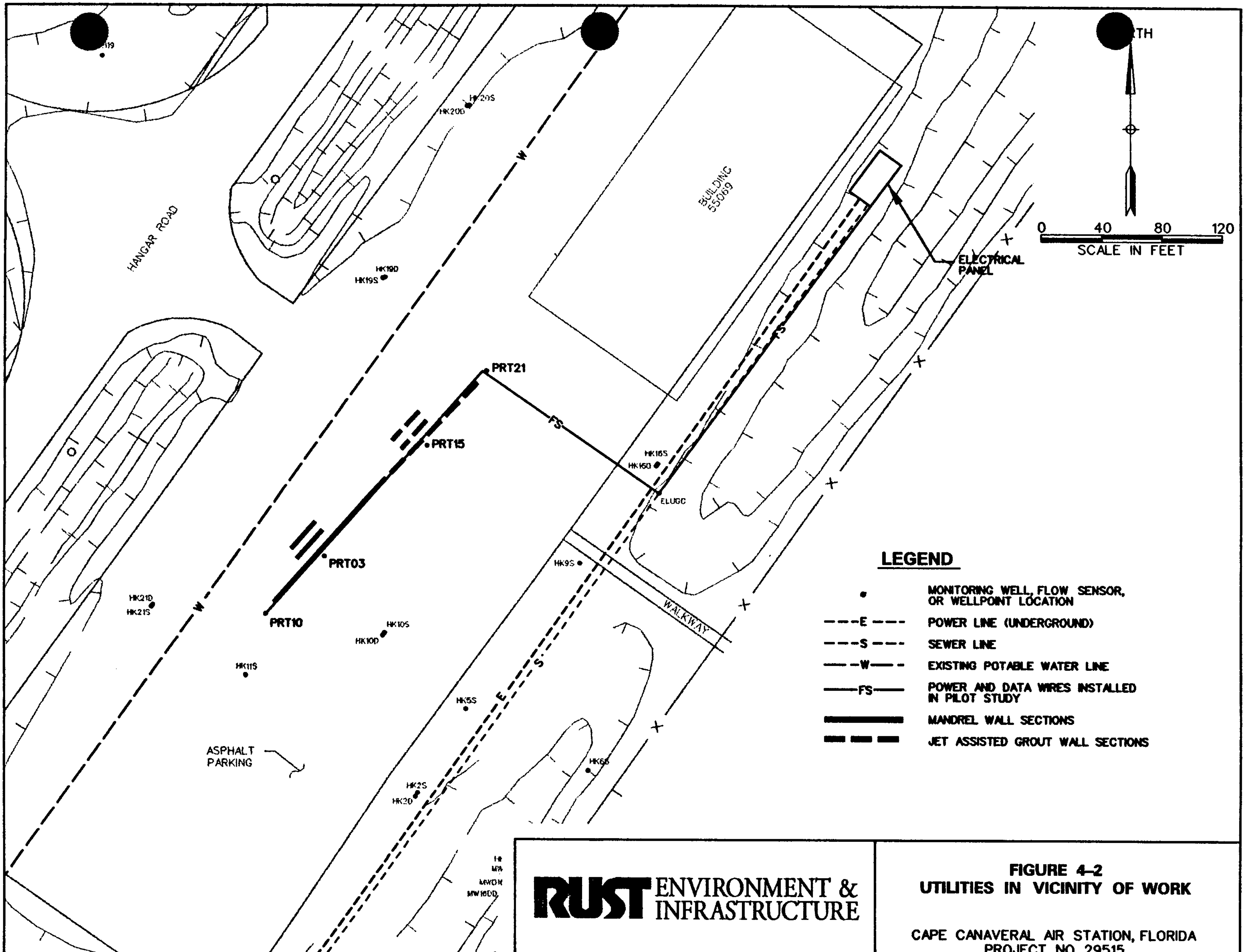


RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-1
GENERALIZED PeRT WALL LAYOUT

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

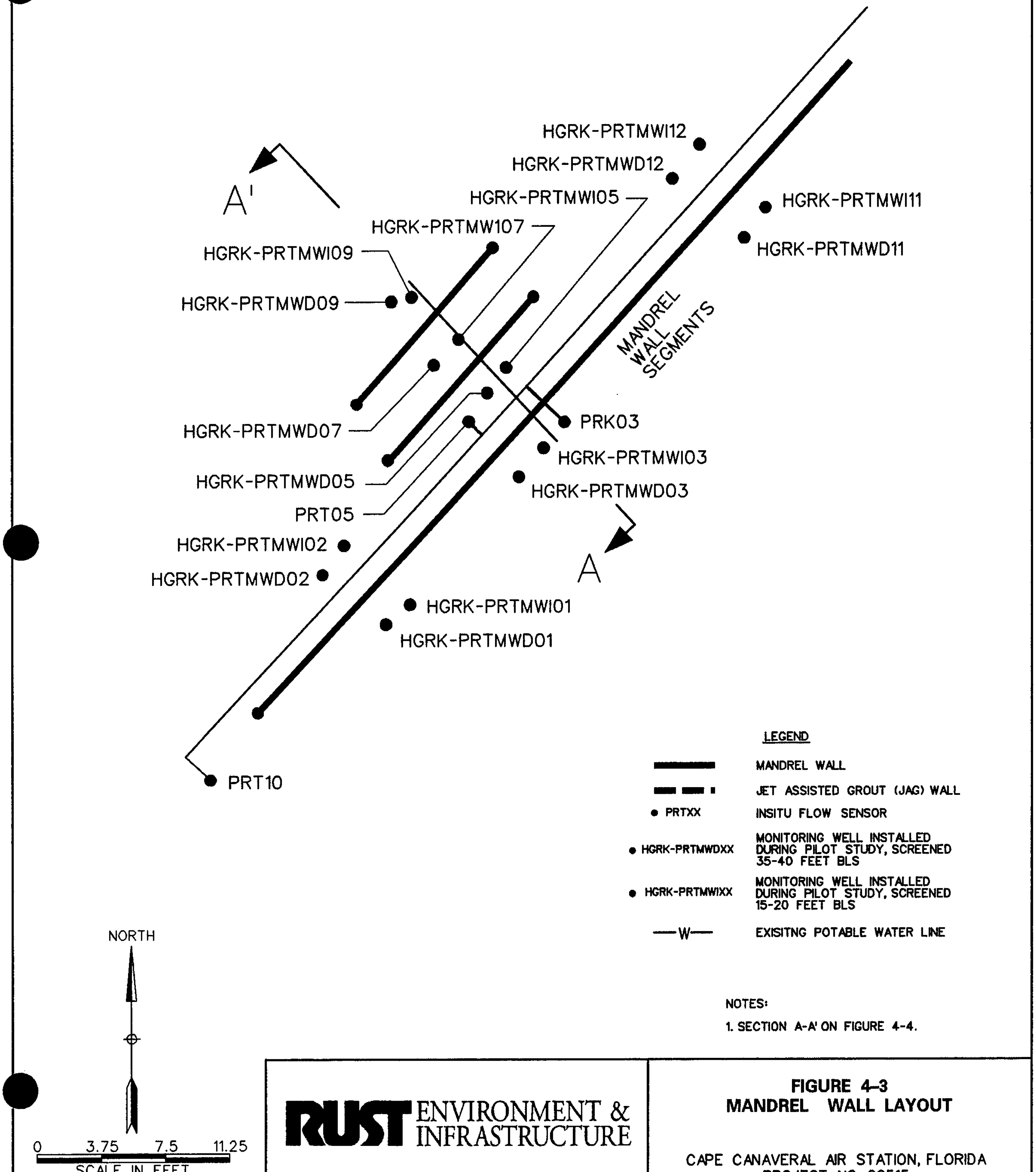
N:\39748\9748HK13.DGN



RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-2
UTILITIES IN VICINITY OF WORK

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515



NOTES:

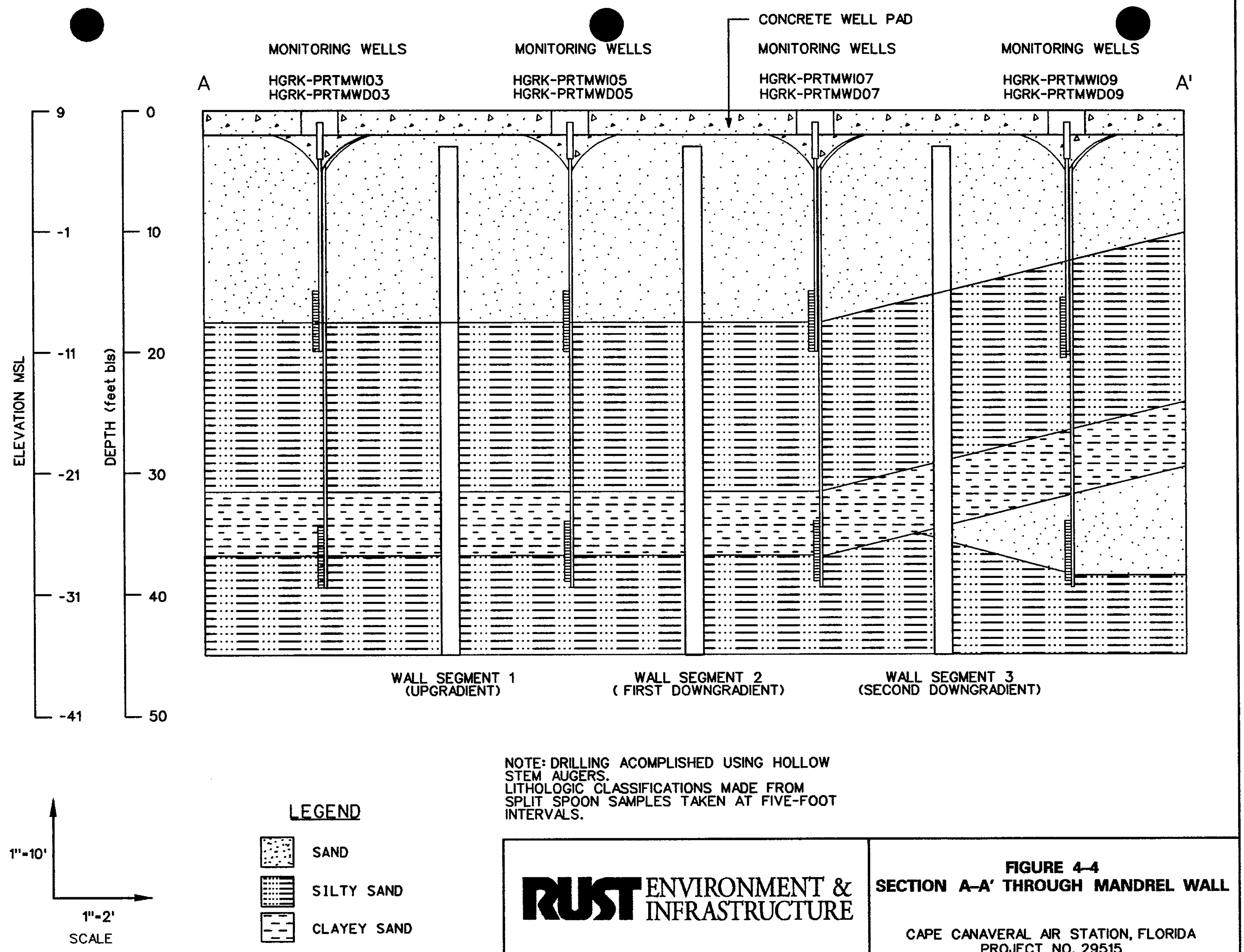
1. SECTION A-A' ON FIGURE 4-4.

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-3
MANDREL WALL LAYOUT

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

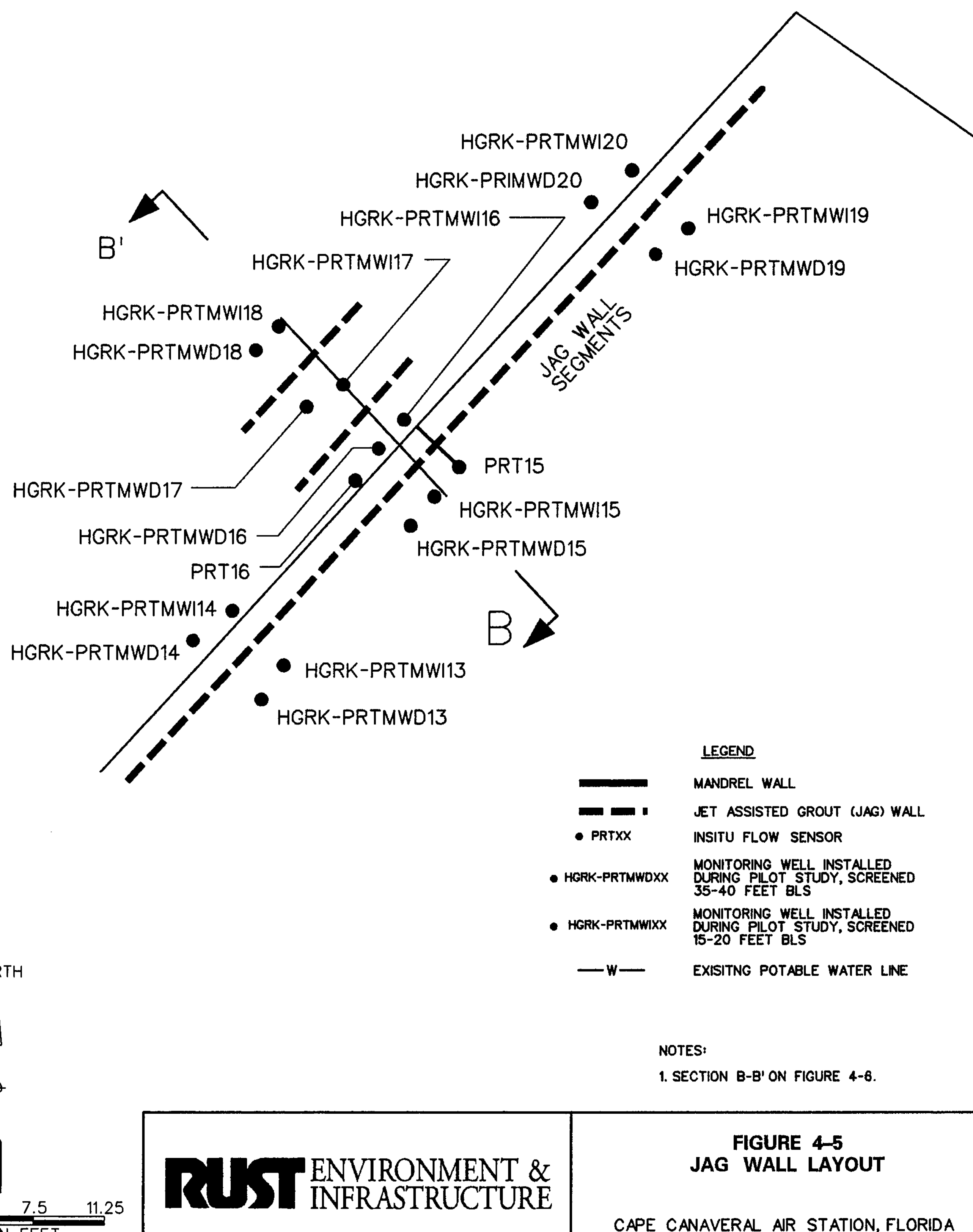
N:\39748\9748HK08.DGN



RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-4
SECTION A-A' THROUGH MANDREL WALL

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515



LEGEND

	MANDREL WALL
	JET ASSISTED GROUT (JAG) WALL
• PRTXX	INSITU FLOW SENSOR
• HGRK-PRTMWDXX	MONITORING WELL INSTALLED DURING PILOT STUDY, SCREENED 35-40 FEET BLS
• HGRK-PRTMWIXX	MONITORING WELL INSTALLED DURING PILOT STUDY, SCREENED 15-20 FEET BLS
—W—	EXISITNG POTABLE WATER LINE

NOTES:

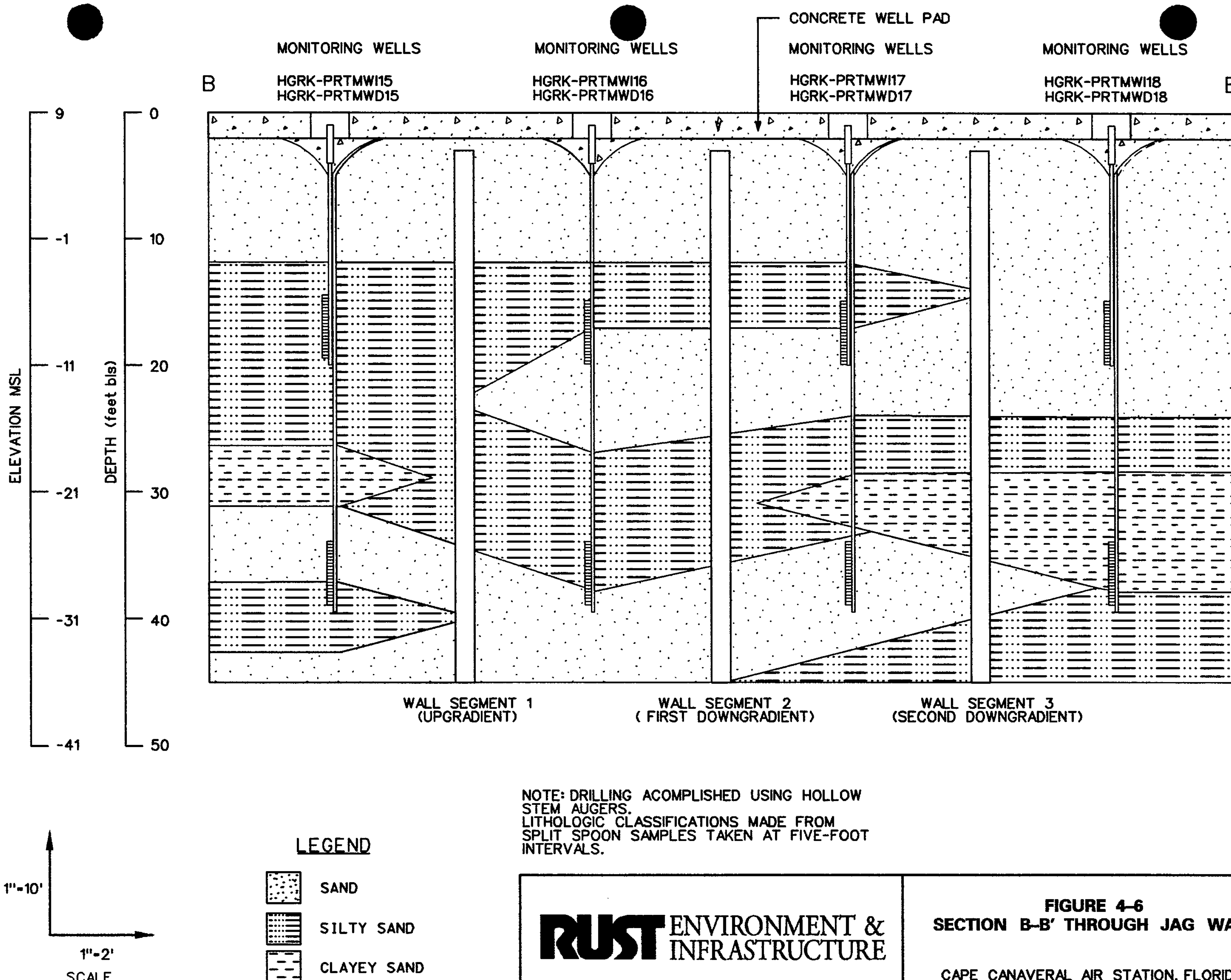
1. SECTION B-B' ON FIGURE 4-6.

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-5
JAG WALL LAYOUT

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK07.DGN

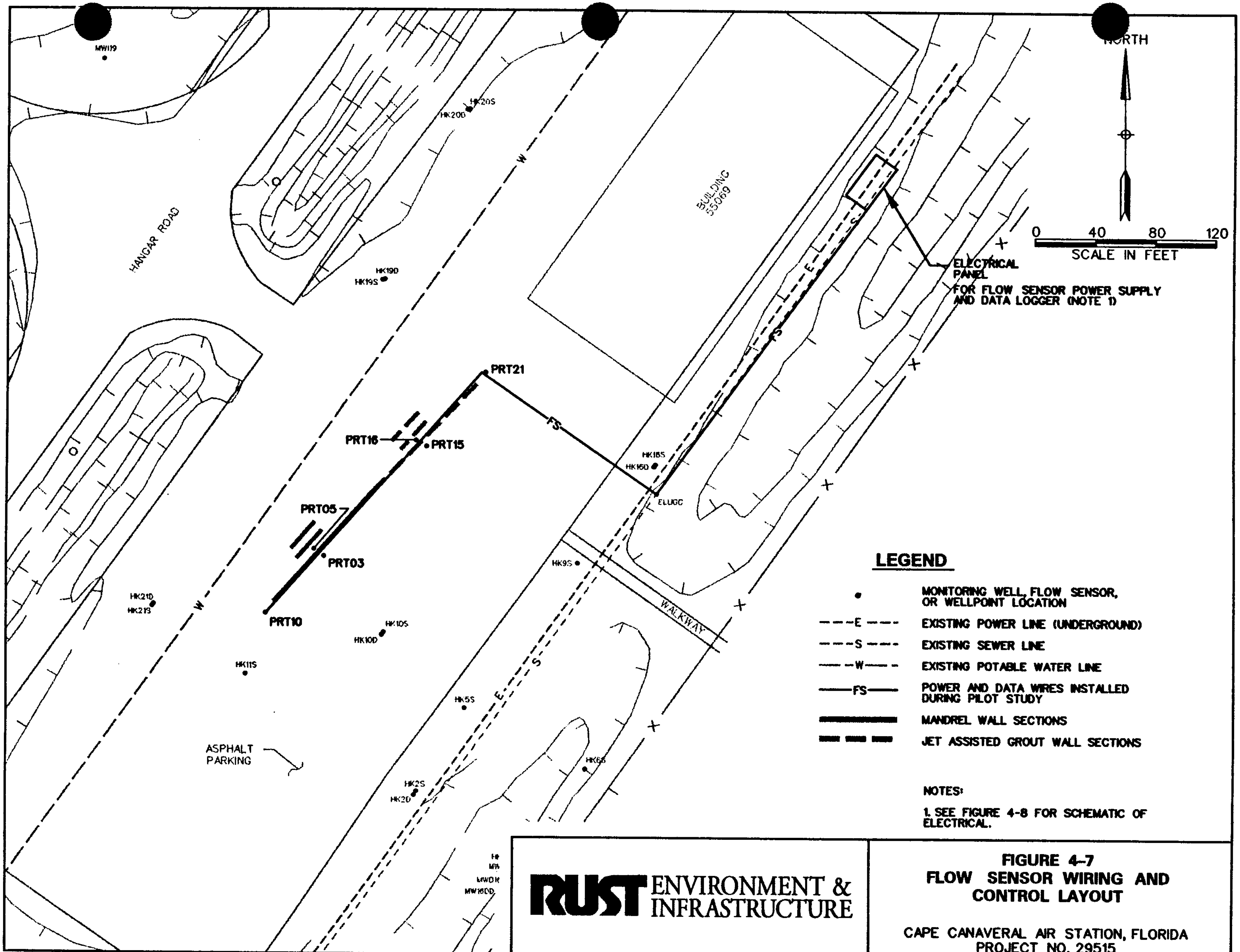


NOTE: DRILLING ACOMPLISHED USING HOLLOW STEM AUGERS.
LITHOLOGIC CLASSIFICATIONS MADE FROM SPLIT SPOON SAMPLES TAKEN AT FIVE-FOOT INTERVALS.

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-6
SECTION B-B' THROUGH JAG WALL

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515



LEGEND

•	MONITORING WELL, FLOW SENSOR, OR WELLPOINT LOCATION
---E---	EXISTING POWER LINE (UNDERGROUND)
---S---	EXISTING SEWER LINE
---W---	EXISTING POTABLE WATER LINE
——FS——	POWER AND DATA WIRES INSTALLED DURING PILOT STUDY
▬▬▬	MANDREL WALL SECTIONS
▬ ▬ ▬	JET ASSISTED GROUT WALL SECTIONS

NOTES:

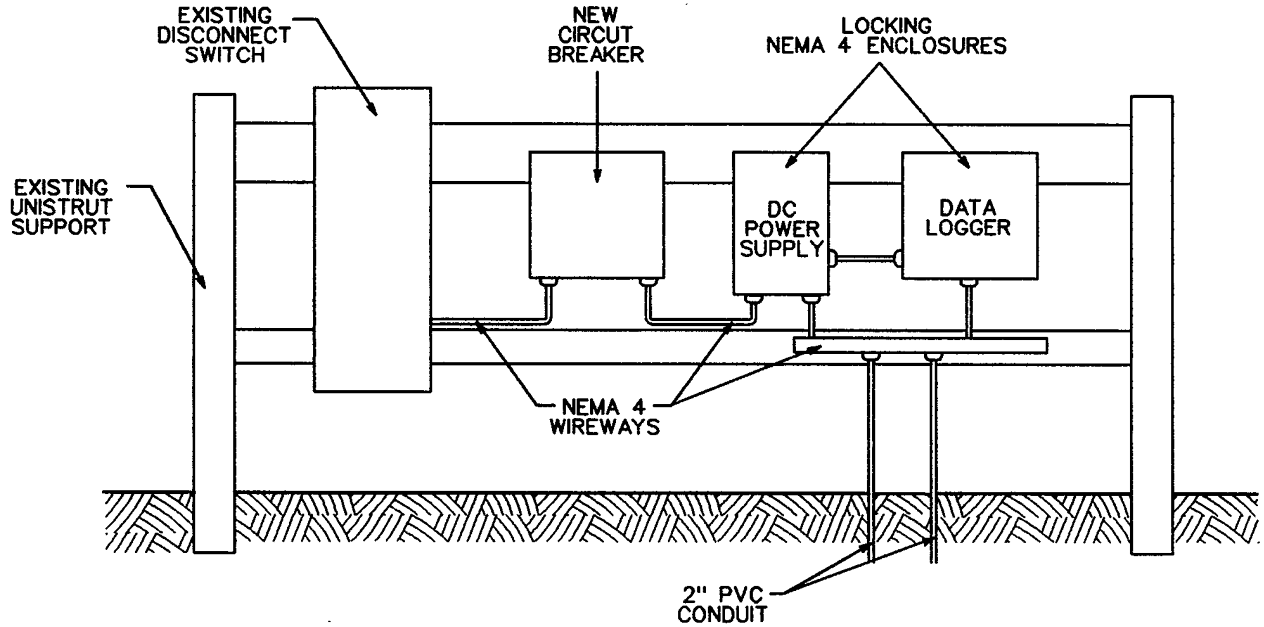
1. SEE FIGURE 4-8 FOR SCHEMATIC OF ELECTRICAL.

RUST ENVIRONMENT & INFRASTRUCTURE

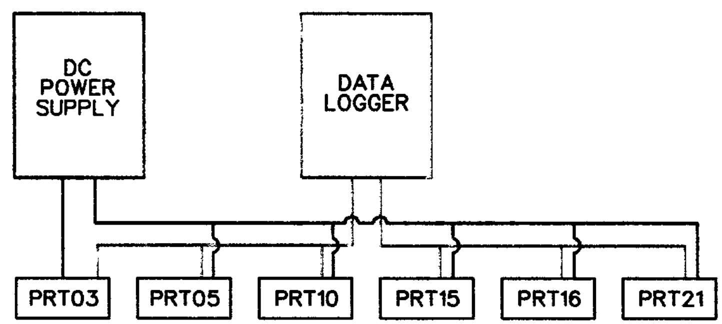
FIGURE 4-7
FLOW SENSOR WIRING AND CONTROL LAYOUT

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK06.DGN



NOT TO SCALE



NOT TO SCALE

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-8
ELECTRICAL AND CONTROL WIRE SCHEMATIC

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

RUST ENVIRONMENT & INFRASTRUCTURE

GROUNDWATER MONITORING INSTALLATION DETAIL

PROJECT: CCAS: PERT WALL PILOT STUDY	JOB NO. 39748 . 10800
LOCATION: CAPE CANAVERAL AIR STATION	INSTALLATION NO. HGRK-PRTMWI01
CLIENT: US AIR FORCE	TYPE OF INSTALLATION 1.25 inch well
CONTRACTOR: US ENVIRONMENTAL	BORING NO. HGRK-PRTMWI01
DRILLER: T. BURKE CERTIFICATION NO: FL-9164	LOCATION Hangar K
RUST FIELD REPRESENTATIVE: C. JACKSON	INSTALLATION DATE 01/18/98

SURVEY DATUM: NGVD

GROUND SURFACE ELEVATION: 8.93 ft.

TYPE OF PROTECTIVE CASING 8-INCH FLUSH MOUNTED

SUMMARIZE SOIL CONDITIONS, BACKFILL AND SEALS (NOT TO SCALE)

10 ft. Sand

15 ft. Sand

20 ft. Sand

10.00 ft.

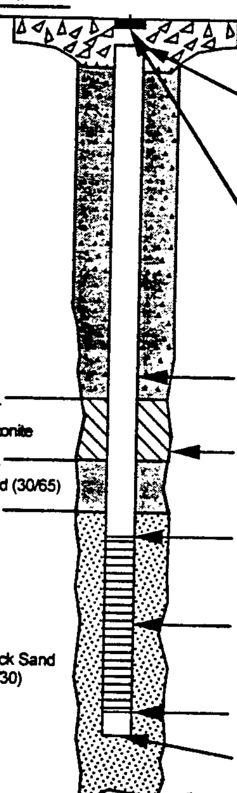
Bentonite

12.00 ft.

Fine Sand (30/65)

13.00 ft.

Filter Pack Sand (20/30)



THICKNESS OF SURFACE SEAL 10.00 ft.

TOP OF WELL CASING OR RISER PIPE EL. 8.76 ft. STICKUP -0.17 ft.

NOTE: CASING IS EXPANDED TO 2 INCH PVC AT SURFACE TO ACCOMODATE A LOCKING CAP.

TYPE OF WELL CASING OR RISER PIPE PVC

INSIDE DIAMETER 1.25 in.

APPROXIMATE DIAMETER OF BOREHOLE 8.0 in.

TOP OF SCREENED INTERVAL EL. -5.24 ft. DEPTH 14.00 ft.

TYPE OF SCREEN Wire Wrap PVC

SCREEN GAUGE OR SIZE OF OPENINGS 0.010 in.

INSIDE DIAMETER 1.25 in.

TYPE OF BACKFILL AROUND SCREEN Filter Sand (20/30)

BOTTOM OF SCREENED INTERVAL EL. -10.24 ft. DEPTH 19.00 ft.

BOTTOM OF WELL EL. -10.24 ft. DEPTH 19.00 ft.

BOTTOM OF BOREHOLE EL. -11.24 ft. DEPTH 20.00 ft.

• FIGURES ABOVE REFER TO DEPTH IN FEET

• ALL DEPTHS ARE REFERENCED TO TOP OF WELL CASING

*NOT TO SCALE

14.00 ft. LENGTH OF RISER PIPE + 5.00 ft. LENGTH OF SCREEN = 19.00 ft. TOTAL

GROUT
BENTONITE SEALS
FINE SAND
FILTER PACK
CONCRETE

901

6/26/98 3:06:04 PM

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-9
TYPICAL WELL CONSTRUCTION DETAIL
INTERMEDIATE WELL

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

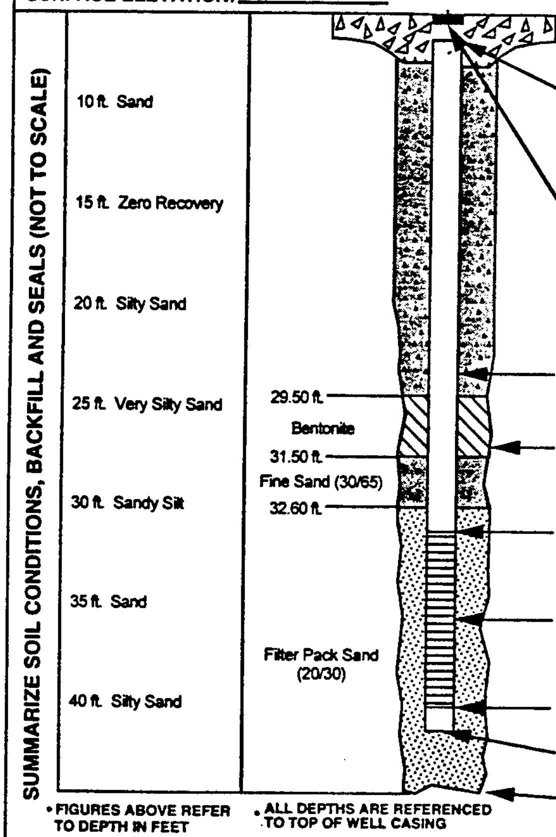
N:\39748\9748HK01.DGN

RUST ENVIRONMENT & INFRASTRUCTURE

GROUNDWATER MONITORING INSTALLATION DETAIL

PROJECT: CCAS: PERT WALL PILOT STUDY
JOB NO. 39748 . 10800
LOCATION: CAPE CANAVERAL AIR STATION
INSTALLATION NO. HGRK-PRTMWD01
CLIENT: US AIR FORCE
TYPE OF INSTALLATION 1.25 inch well
CONTRACTOR: US ENVIRONMENTAL
BORING NO. HGRK-PRTMWD01
DRILLER: T. BURKE **CERTIFICATION NO:** FL-9164
LOCATION Hangar K
RUST FIELD REPRESENTATIVE: C. JACKSON
INSTALLATION DATE 01/18/98

SURVEY DATUM: NGVD
GROUND SURFACE ELEVATION: 8.93 ft.
TYPE OF PROTECTIVE CASING 8-INCH FLUSH MOUNTED



THICKNESS OF SURFACE SEAL 29.50 ft.

TOP OF WELL CASING OR RISER PIPE EL. 8.76 ft. STICKUP -0.17 ft.

NOTE: CASING IS EXPANDED TO 2 INCH PVC AT SURFACE TO ACCOMODATE A LOCKING CAP.

TYPE OF WELL CASING OR RISER PIPE PVC
INSIDE DIAMETER 1.25 in.

APPROXIMATE DIAMETER OF BOREHOLE 8.0 in.

TOP OF SCREENED INTERVAL EL. -25.26 ft. DEPTH 34.02 ft.

TYPE OF SCREEN Wire Wrap PVC
SCREEN GAUGE OR SIZE OF OPENINGS 0.010 in.
INSIDE DIAMETER 1.25 in.
TYPE OF BACKFILL AROUND SCREEN Filter Sand (20/30)

BOTTOM OF SCREENED INTERVAL EL. -30.26 ft. DEPTH 39.02 ft.

BOTTOM OF WELL EL. -30.26 ft. DEPTH 39.02 ft.

BOTTOM OF BOREHOLE EL. -31.26 ft. DEPTH 40.02 ft.

• FIGURES ABOVE REFER TO DEPTH IN FEET
• ALL DEPTHS ARE REFERENCED TO TOP OF WELL CASING

*NOT TO SCALE

34.02 ft. (LENGTH OF RISER PIPE) + 5.00 ft. (LENGTH OF SCREEN) = 39.02 ft. (TOTAL)

Legend
GROUT
BENTONITE SEALS
FINE SAND
FILTER PACK
CONCRETE

900

6/26/98 3:06:04 PM

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-10
TYPICAL WELL CONSTRUCTION DETAIL
DEEP WELL

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK02.DGN

RUST ENVIRONMENT & INFRASTRUCTURE

MONITORING WELL DEVELOPMENT LOG

Date Started (yr/mo/dy) 98/1/24 Date Completed (yr/mo/dy) 98/1/24

Field Personnel CRAIG JACKSON

Project CCAS: PERT WALL PILOT STUDY

Site Name HANGAR K

RUST Job # 39748

Well ID # HGRK-PRTMWI01

☐ Upgradient ☐ Downgradient ☐ Sidegradient ☐ Source

Weather Conditions

Air Temperature °F

Total Well Depth (TWD) = From Top of Well Casing 20.00 1/100 ft

Depth to Groundwater (DGW) = From Top of Well Casing 5.00 1/100 ft

Length of Water Column (LWC) = TWD - DGW = 15.00 1/100 ft

1 Casing Volume (OCV) = LWC X 0.060 = 0.90 gallons

5 Casing Volumes = 4.50 gallons

Method of Well Development SWABBING AND PUMPING

Total Volume of Water Removed 80 gallons

Date/Time (yr/mo/dy/Military)		Discharge Rate (gpm)	Cumulative Volume Purged (gal)	Water Temp (°C)	pH	Electric Conductivity (mmho)	Turbidity/Color (NTU's)	Sand Content (%)	Remarks
98/1/24	0932		0					—	BEGIN DEVELOPING
98/1/24	0938	6.7	40	25.5	8.25	0.340	3.8	—	
98/1/24	0941	6.7	60	25.6	8.48	0.343	5.76	—	
98/1/24	0944	6.7	80	25.7	8.62	0.346	5.51	—	STOP DEVELOPING NOTE: 1) WATER CLEAR

COMMENTS/ OBSERVATIONS

MWDEV 6/10/98 9:46:12 AM

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-11
TYPICAL WELL DEVELOPMENT RECORD
INTERMEDIATE WELL

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK03.DGN

RUST ENVIRONMENT & INFRASTRUCTURE

MONITORING WELL DEVELOPMENT LOG

Date Started (yr/mo/dy) 98/1/24 Date Completed (yr/mo/dy) 98/1/24
Field Personnel CRAIG JACKSON
Project CCAS: PERT WALL PILOT STUDY
Site Name HANGAR K
RUST Job # 39748
Well ID # HGRK-PRTMWD01
☐ Upgradient ☐ Downgradient ☐ Sidegradient ☐ Source
Weather Conditions
Air Temperature ______ °F

Total Well Depth (TWD) = From Top of Well Casing 40.00 1/100 ft
Depth to Groundwater (DGW) = From Top of Well Casing 5.00 1/100 ft
Length of Water Column (LWC) = TWD - DGW = 35.00 1/100 ft
1 Casing Volume (OCV) = LWC X 0.060 = 2.10 gallons
5 Casing Volumes = 10.50 gallons
Method of Well Development SWABBING AND PUMPING
Total Volume of Water Removed 120 gallons

Date/Time (yr/mo/dy/Military)		Discharge Rate (gpm)	Cumulative Volume Purged (gal)	Water Temp (°C)	pH	Electric Conductivity (mmho)	Turbidity/Color (NTU's)	Sand Content (%)	Remarks
98/1/24	1048		0					—	BEGIN DEVELOPING
98/1/24	1057	4.4	40	25.5	8.63	1.15	40.03	—	
98/1/24	1106	4.4	80	25.6	8.57	1.17	15.94	—	
98/1/24	1111	4.0	100	25.8	8.56	1.17	12.37	—	
98/1/24	1116	4.0	120	25.7	8.54	1.17	11.13	—	STOP DEVELOPING NOTE: 1) WATER CLEAR

COMMENTS/ OBSERVATIONS

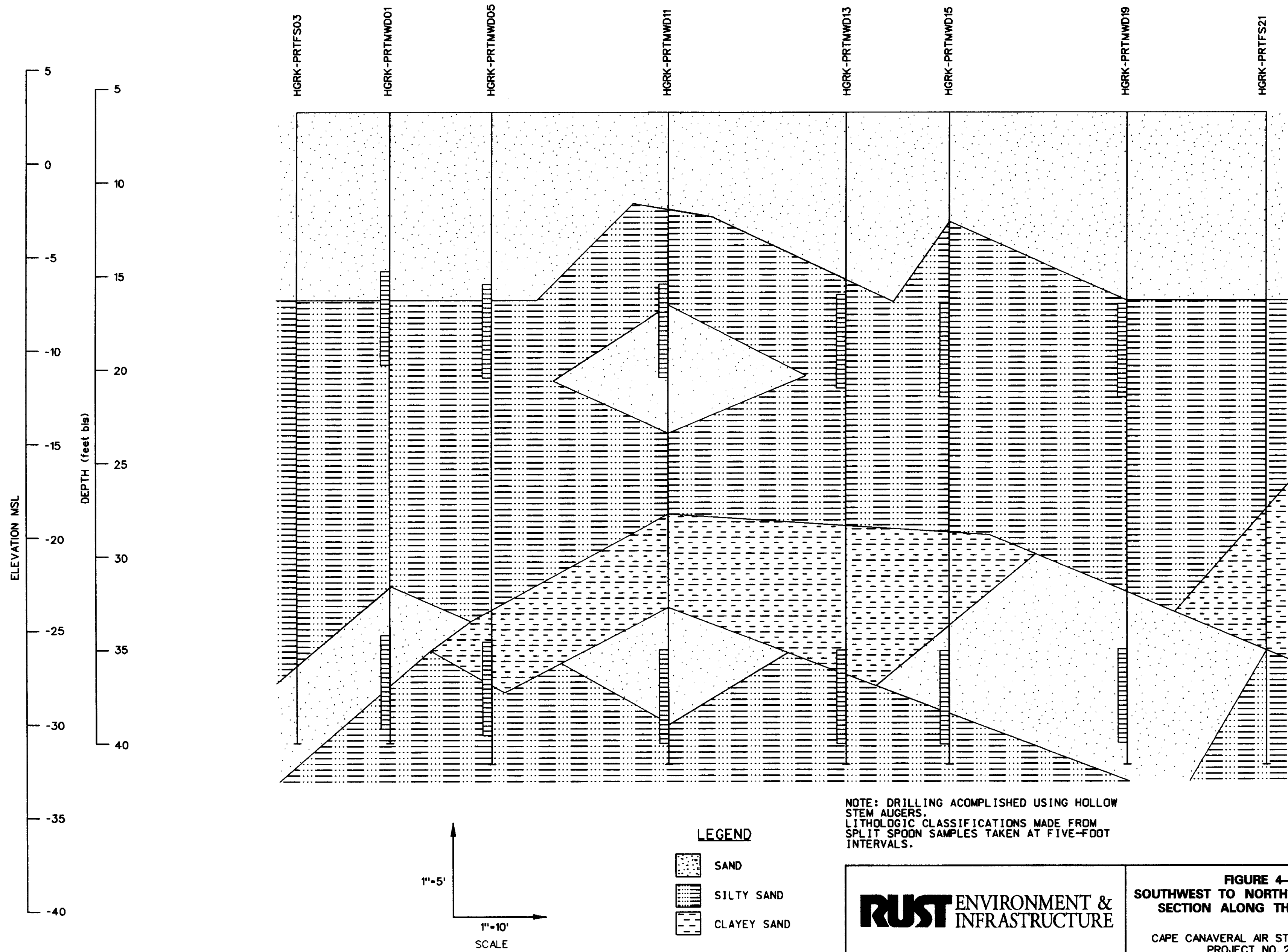
MWDEV 6/10/98 9:46:21 AM

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-12
TYPICAL WELL DEVELOPMENT RECORD
DEEP WELL

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK04.DGN



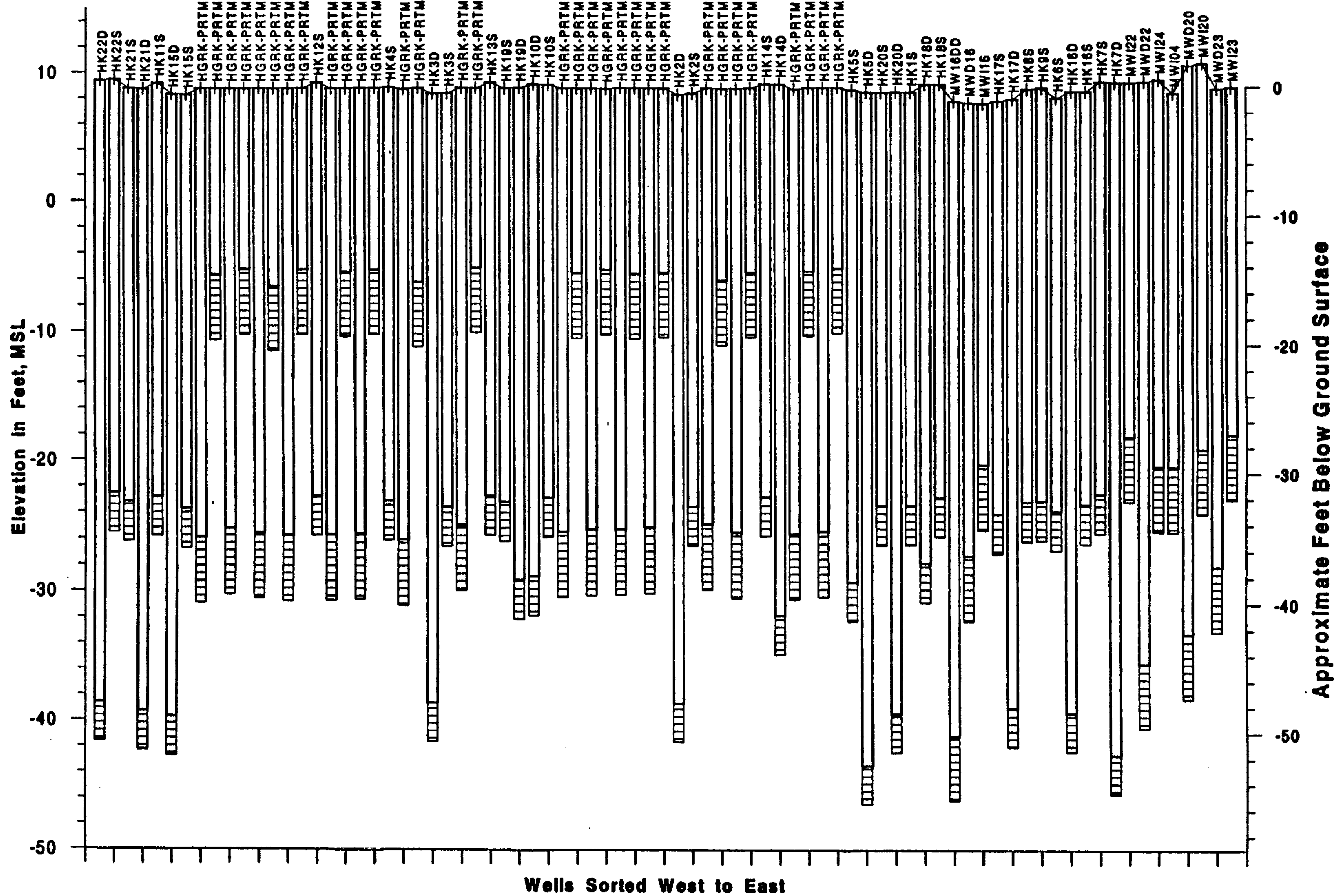
NOTE: DRILLING ACOMPLISHED USING HOLLOW STEM AUGERS.
LITHOLOGIC CLASSIFICATIONS MADE FROM SPLIT SPOON SAMPLES TAKEN AT FIVE-FOOT INTERVALS.

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-13
SOUTHWEST TO NORTHEAST GEOLOGIC SECTION ALONG THE PeRT WALL

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK18.DGN



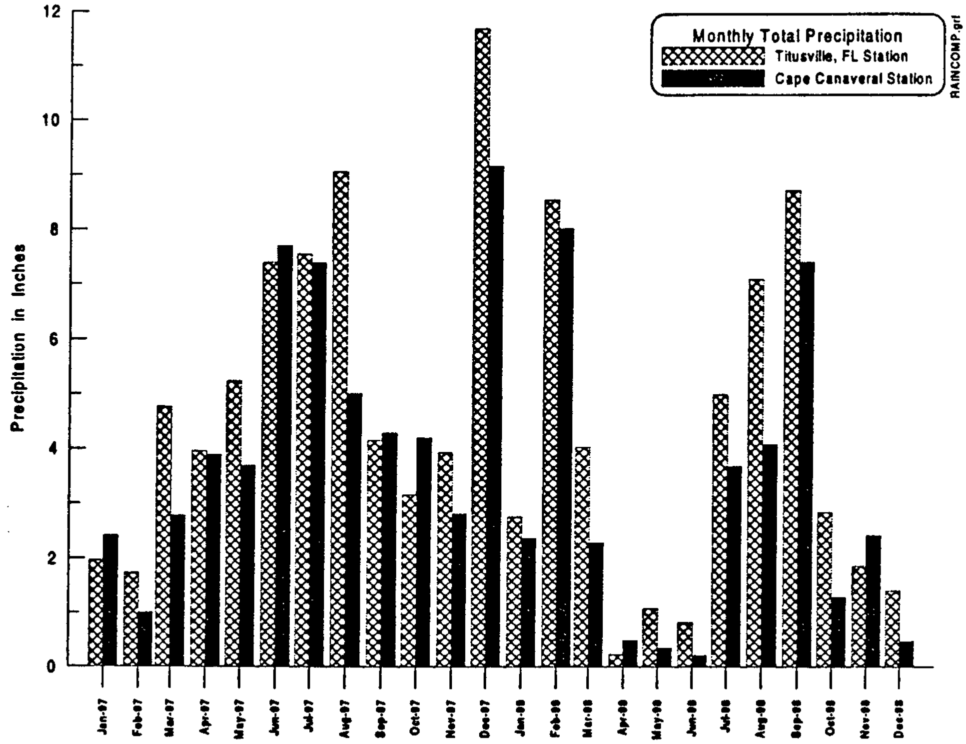
RUST

Rust Environment & Infrastructure

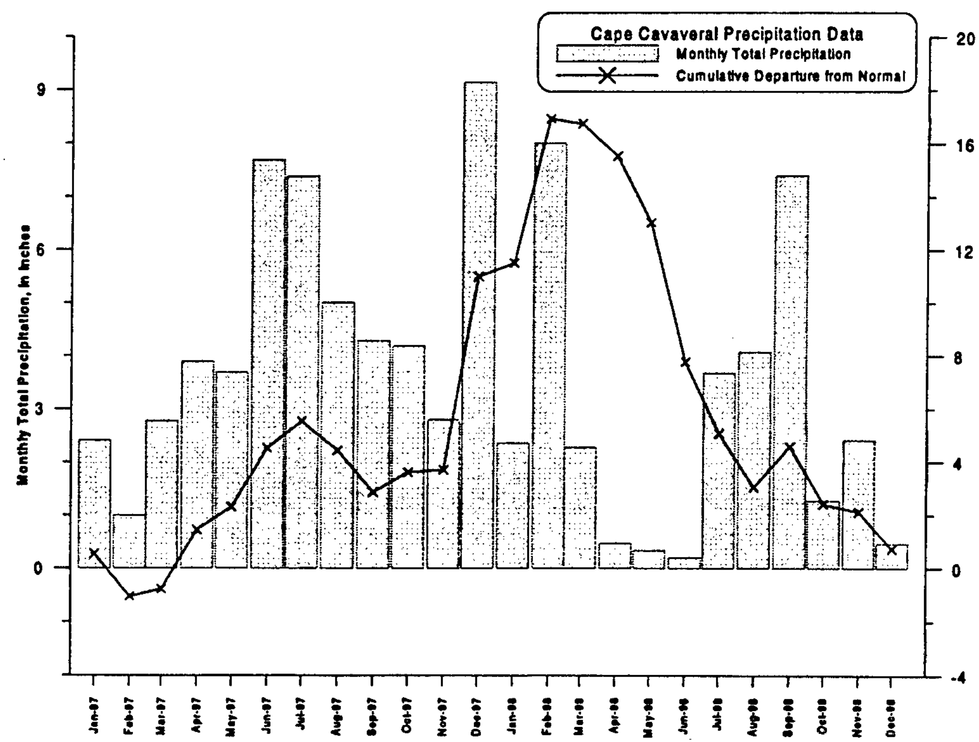
FIGURE 4-14
Monitoring Well Screened Intervals,
Hanger K Vicinity

Cape Canaveral Air Station, Florida

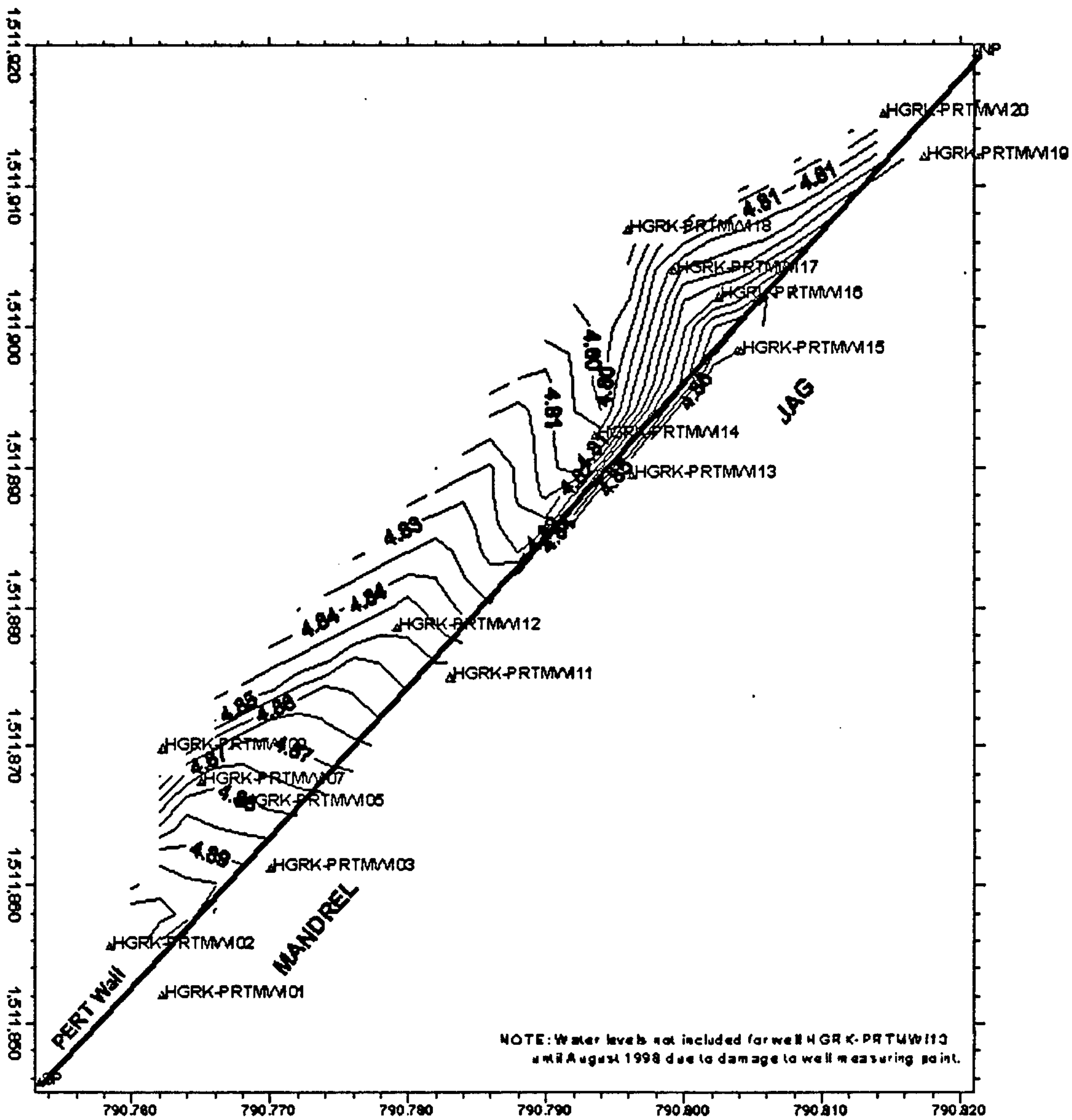
Data/Graphics/29515/F_4-14.0s8



COMPARISON OF MONTHLY PRECIPITATION TOTALS NEAR HANGAR K



RUST **Rust Environment & Infrastructure**	FIGURE 4-15 Precipitation Data Cape Canaveral Air Station, Florida



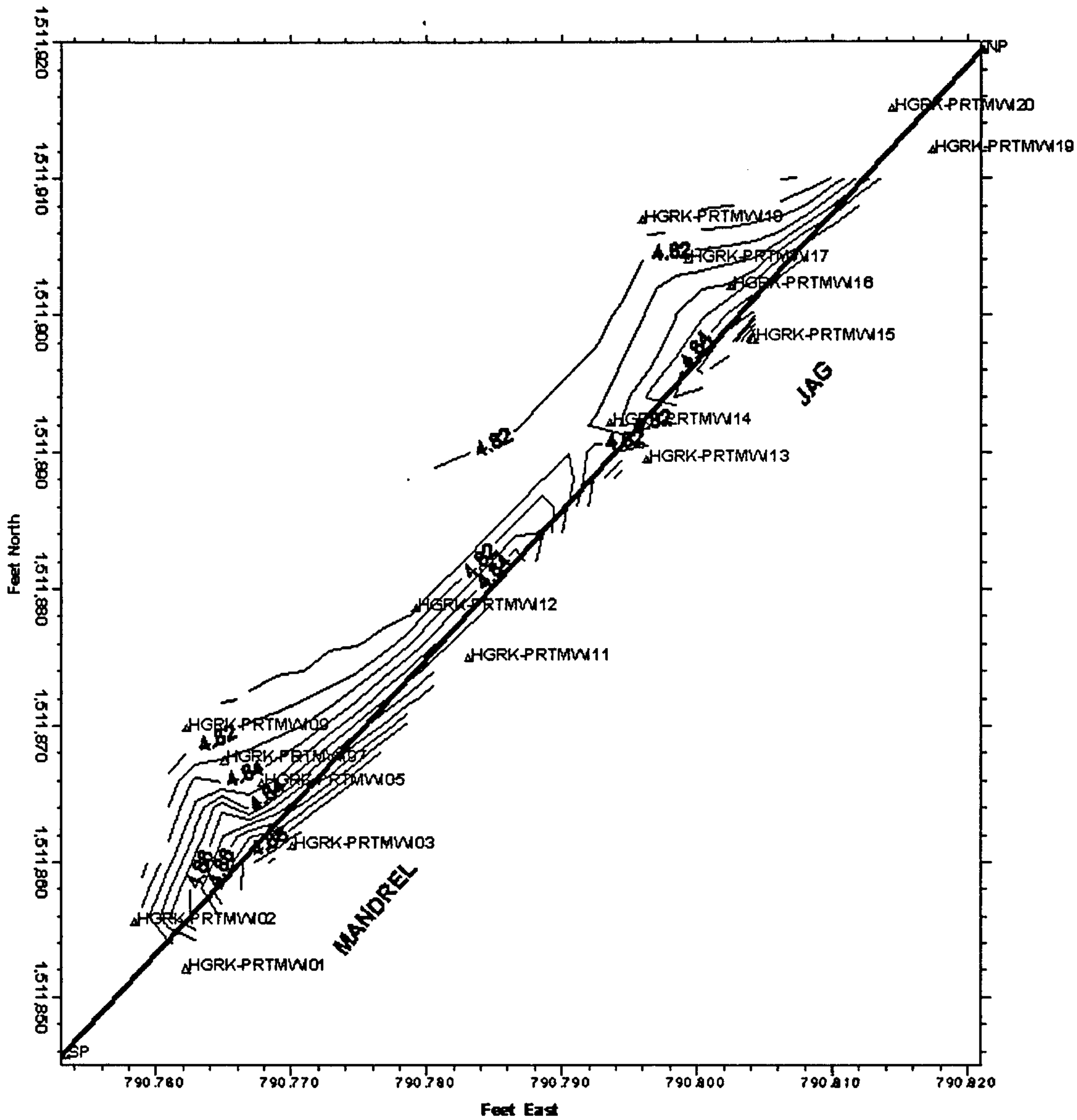
RUST

Rust Environment & Infrastructure

FIGURE 4-16
Potentiometric Surface Map
February 1998, Wells Screened 15 to 20 feet bls

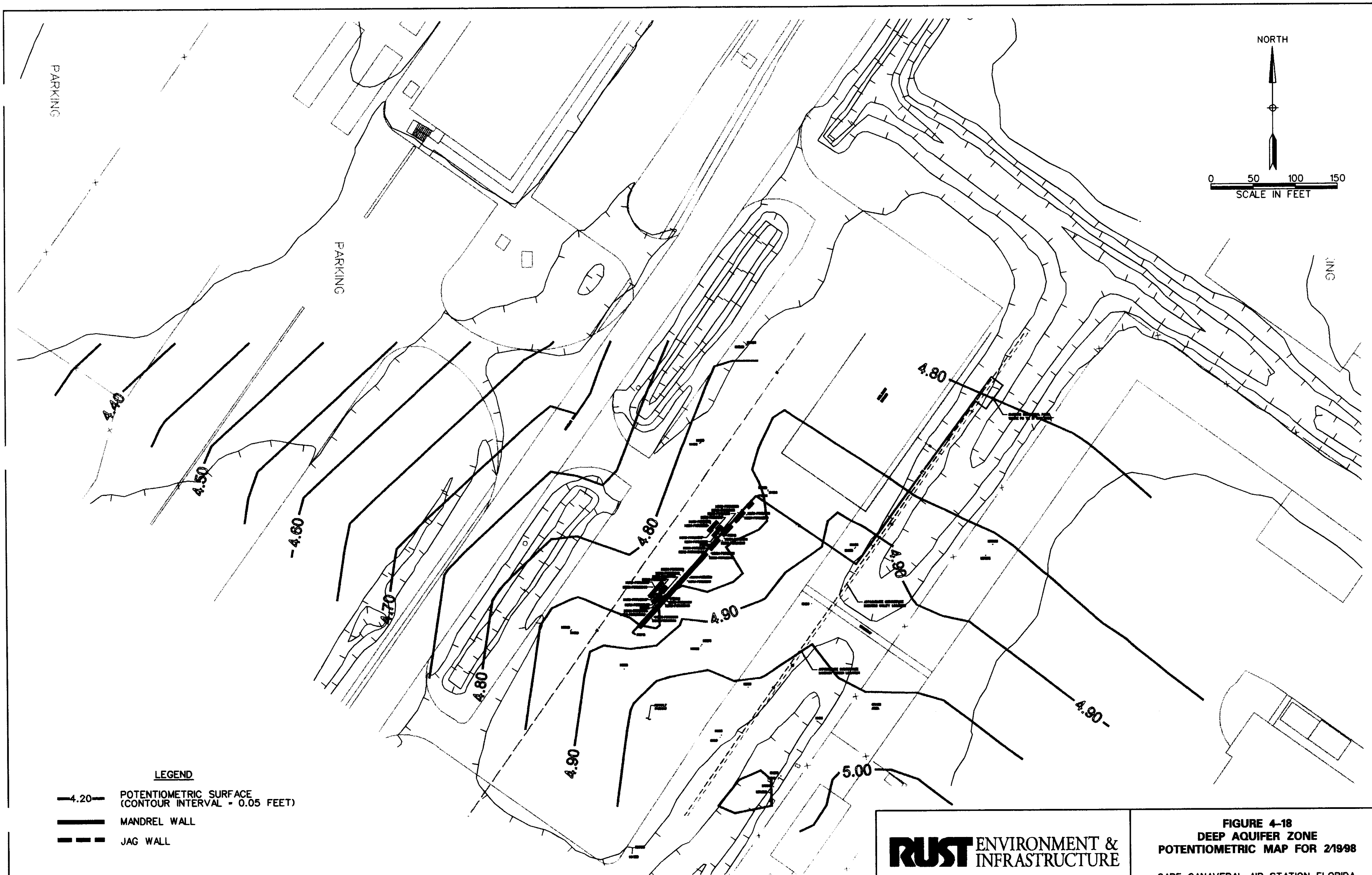
Cape Canaveral Air Station, Florida

Data/Graphics/29515/F_4-16.fh8



RUST **Rust Environment & Infrastructure**	FIGURE 4-17 Potentiometric Surface Map February 1998, Wells Screened 35 to 40 feet bls Cape Canaveral Air Station, Florida

Data/Graphics/29515/F_4-20.fh8



LEGEND

—4.20— POTENTIOMETRIC SURFACE (CONTOUR INTERVAL = 0.05 FEET)

MANDREL WALL

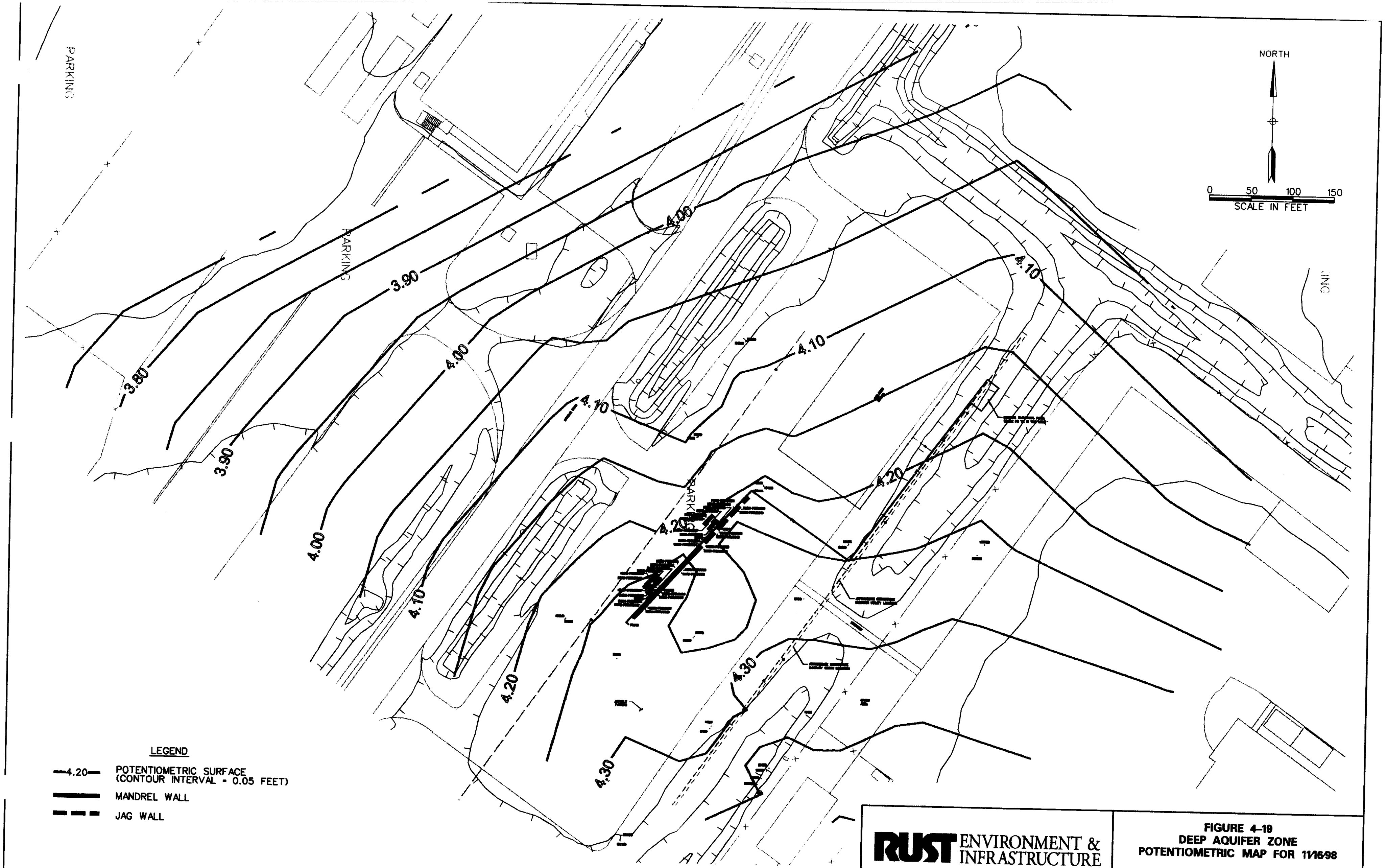
JAG WALL

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-18
DEEP AQUIFER ZONE
POTENTIOMETRIC MAP FOR 2/19/98

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK21.DGN

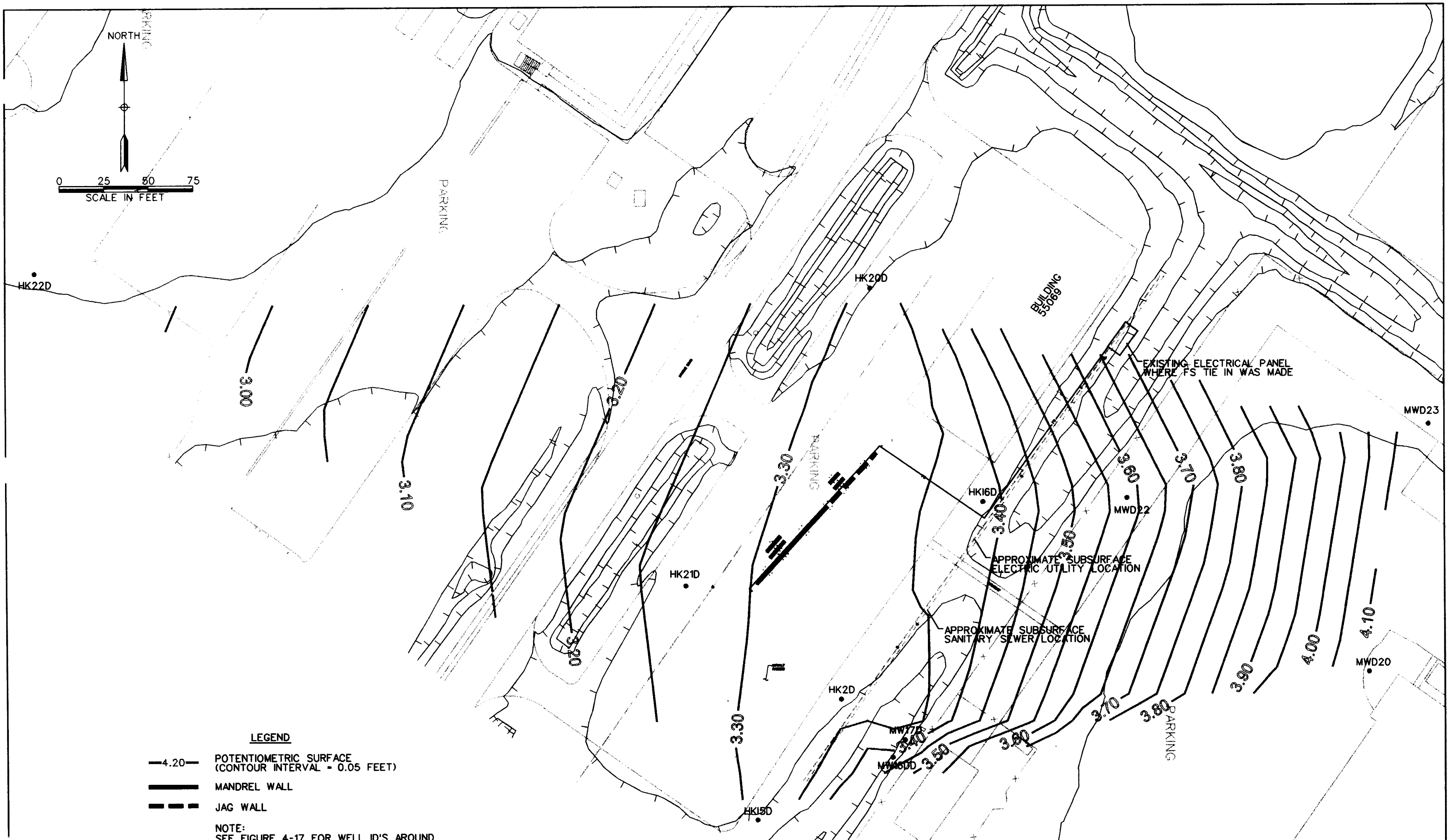


RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-19
DEEP AQUIFER ZONE
POTENTIOMETRIC MAP FOR 11/16/98

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK19.DGN



LEGEND

—4.20— POTENTIOMETRIC SURFACE (CONTOUR INTERVAL = 0.05 FEET)

MANDREL WALL

JAG WALL

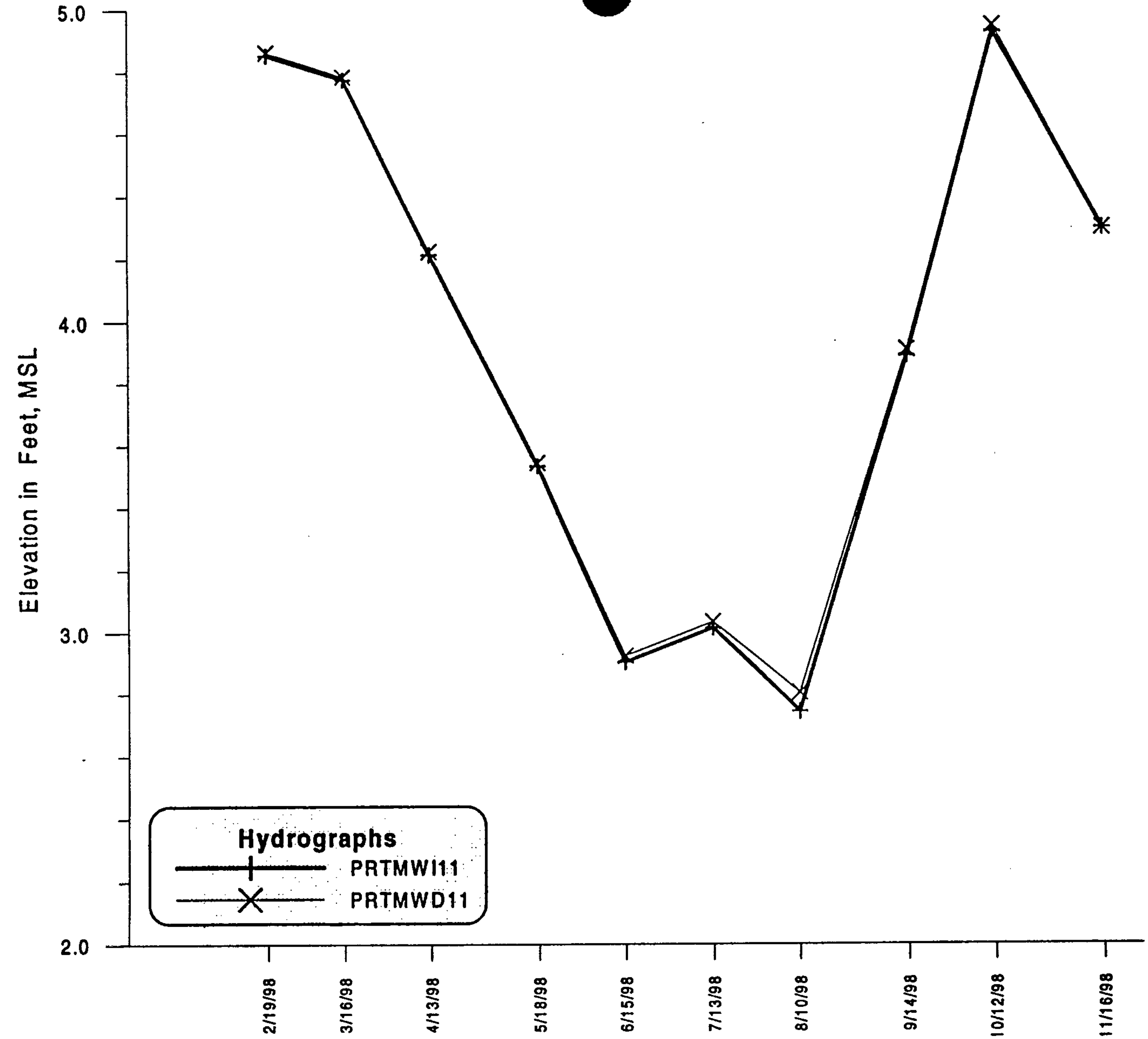
NOTE:
SEE FIGURE 4-17 FOR WELL ID'S AROUND WALL SEGMENT

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 4-20
BOTTOM AQUIFER ZONE
POTENTIOMETRIC MAP FOR 11/16/98

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK20.DGN



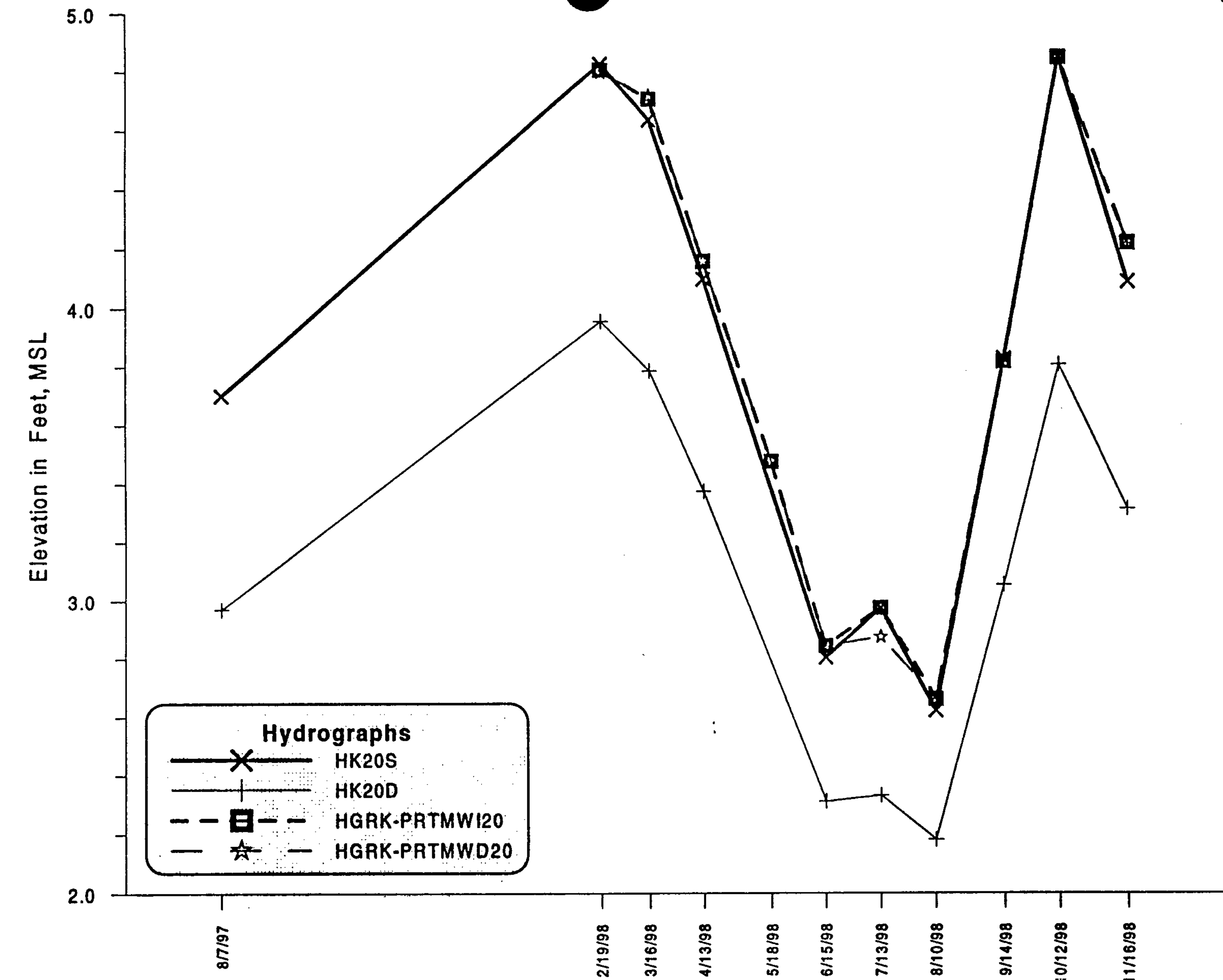
Rust Environment & Infrastructure

FIGURE 4-21

Hydrographs of PRTMWI11 and PRTMWD11

Cape Canaveral Air Station, Florida

Data/Graphics/29515/F_4-22Hydrog.thx



Rust Environment & Infrastructure

FIGURE 4-22

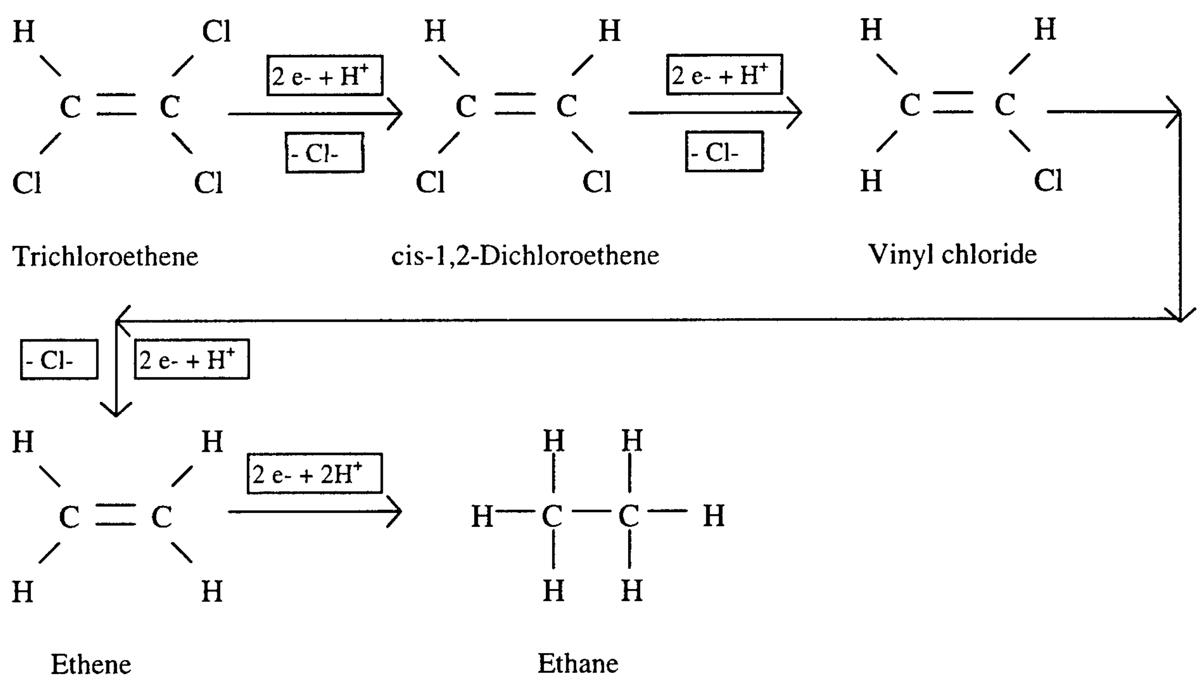
Hydrographs of HK20S, HK20D, HGRK-PRTMWI20 and HGRK-PRTMWD20

Data/Graphics/29515/F_4-22Hydrog.thX

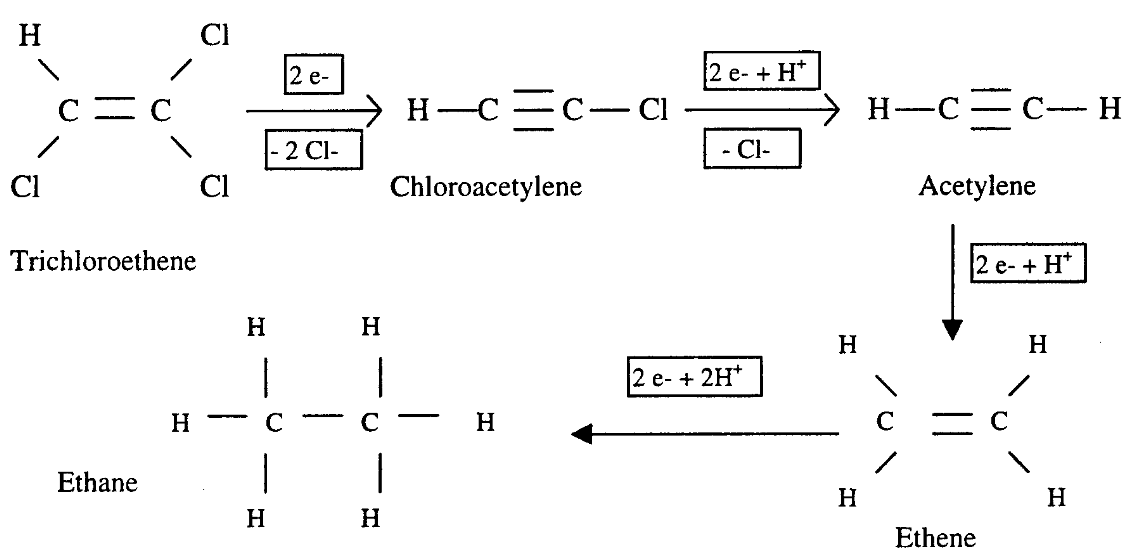
5.0 REACTION MECHANISMS

The primary reaction is believed to be an oxidation of the Fe^0 to Fe^{+2} or Fe^{+3} and subsequent reduction of the chlorinated organics. In a U.S. EPA Remedial Technology Fact Sheet (U.S. EPA, 1997), the progressive reduction of TCE to c-DCE, and vinyl chloride to ethene, ethane and acetylene are shown as two competing reactions:

A: Sequential Hydrogenolysis



B: Reductive β elimination



Some c-DCE will undergo a "beta" elimination, but the proportions will be less than for TCE (Roberts, et. al., 1996).

5.1 REACTION RATES

The most highly concentrated chlorinated VOCs at the Cape Canaveral PeRT wall site are c-DCE and vinyl chloride. Fe^{+0} degrades these compounds to non-chlorinated hydrocarbons such as ethene by reductive dechlorination by the pathways discussed above. The rate of decrease in concentration of chlorinated VOCs by Fe^{+0} follows a first order rate equation (Matheson and Tratnyek, 1994; Johnson et al., 1996):

$$C = C_o e^{-kt}$$

where C = concentration at time t
C_o = initial concentration
k = a rate constant
t = time

The rate constant can be calculated from the half-life ($t_{1/2}$) as:

$$k = 0.693/\, t_{1/2}$$

The rate constants vary somewhat with temperature, surface area of Fe^{+0}, and solution composition, and are determined under controlled laboratory conditions. It has been shown that rate constants measured for a wide variety of solution compositions at room temperature are similar if they are normalized to Fe^{+0} surface area (Johnson et al., 1996). Values of half-lives from the literature were used to estimate rate constants in lieu of determining site-specific constants. The half-lives presented below were provided by EnviroMetal Technologies, Inc. (ETI). These half-lives are twice the laboratory values to adjust for possible temperature variation between the laboratory and the in situ conditions. Initial concentrations used in the calculations are averages of the concentrations in the six up-gradient wells in November 1998. An experimentally determined conversion factor was used to account for the amount of c-DCE

that transforms to vinyl chloride. A conversion factor of 2% was determined by ETI from numerous experiments using contaminated groundwater from other sites:

Parameters Used in the Residence Time Calculations

VOC	Initial Conc. (ug/L)	Half Life (hr)	Conversion Factor
c-DCE	115,300	8.3	2%
vinyl chloride	57,083	12.8	na

na = not applicable

Using the parameters above, the concentrations of c-DCE and vinyl chloride over a 200 hour period were calculated (Figure 5-1). Concentrations of c-DCE and vinyl chloride are reduced by 95% in 36 and 58 hours, respectively. Concentrations of c-DCE and vinyl chloride are reduced to the EPA Maximum Contaminant Levels (MCLs) for drinking water (7 ug/L for c-DCE and 2 ug/L for vinyl chloride) in 117 and 192 hours, respectively. Thus, a theoretical reaction time of 192 hours is required to reduce all chlorinated VOCs to below MCLs. There are limited data that suggest reaction rates may be lower when VOC concentrations are very high. The c-DCE and vinyl chloride concentrations measured in this pilot study are high enough that their reaction rates could be affected, although no correction has been made for this possibility.

Residence time refers to the length of time that the groundwater is in contact with the Fe^{+0}. Residence time is calculated from the thickness of the Fe^{+0} wall and the groundwater flow rate. The groundwater flow rate at the PeRT wall site is estimated at 0.025 ft/day (see Section 4). For this flow rate, the residence time in a 4-inch wall is 320 hours. Thus, a single 4-inch wall of Fe^{+0} should be capable of degrading the chlorinated VOCs to concentrations less than their MCLs. However, this also means that it would take almost a year for a water molecule to travel from the start of the first wall to exit the third wall, assuming flow follows a straight path between the three PeRT wall segments.

The half-lives used in the calculations are conservative and it is likely that the required residence time of 192 hours is overestimated. Even this conservative estimate, however, indicates that c-DCE and vinyl chloride should degrade substantially more than is observed. Concentrations are observed to decrease only a small amount (and in many cases they increase) across the 4-inch Fe^{+0} walls. Possible explanations for the elevated concentrations observed down-gradient of the PeRT walls are discussed in Section 4.

5.2 INORGANIC REACTIONS

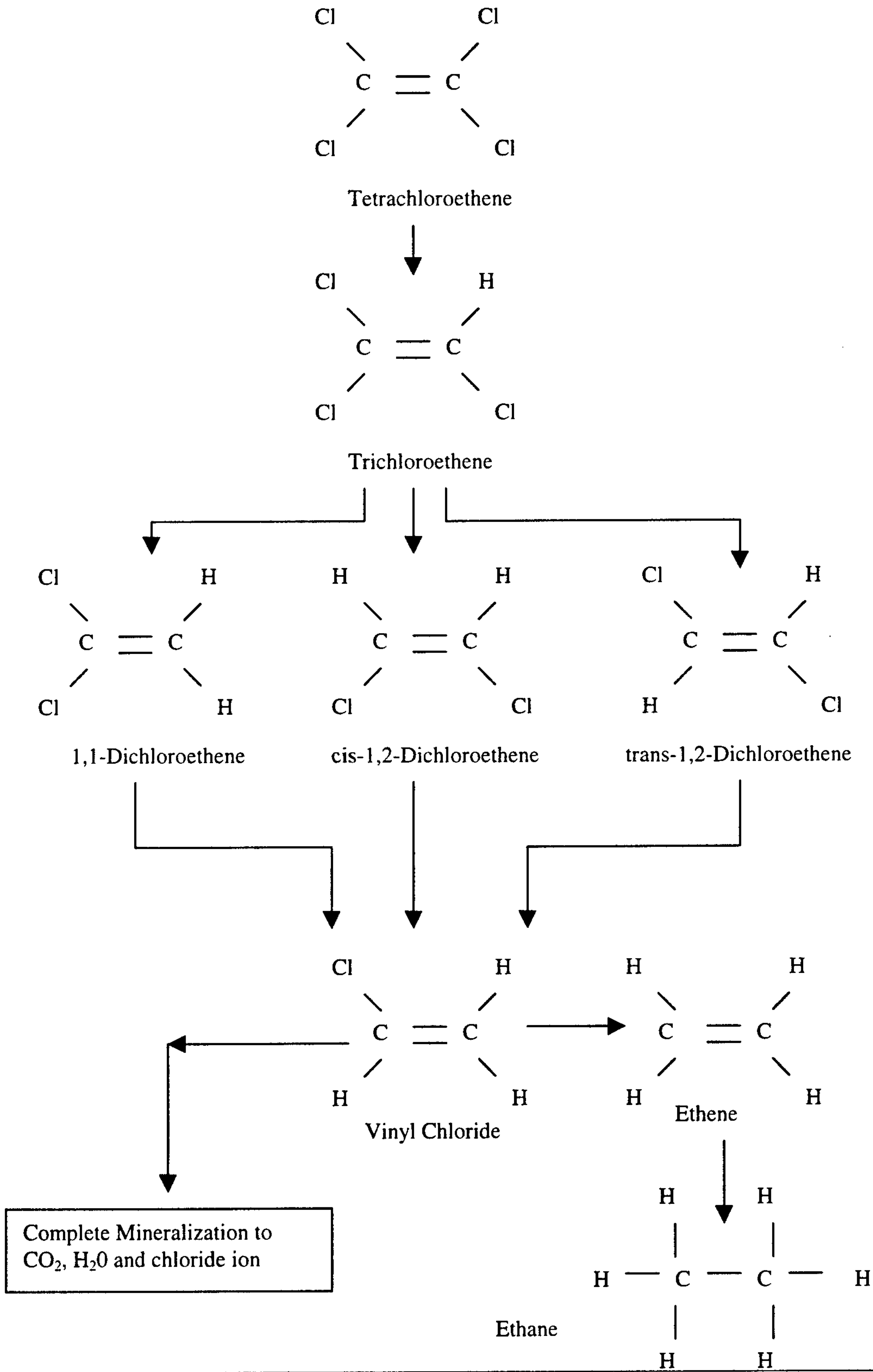
Chemical reactions that occur in the wall can lead to mineral precipitation and gas formation. The reaction products can decrease the ability to degrade chlorinated VOC. The inorganic reactions are listed in Table 5-1.

During reductive dehalogenation, chlorinated VOCs accept electrons and protons which leads to a decrease in oxidation potential and an increase in pH (Reactions A. and B. above). The electrons are provided by the dissolution of Fe^{+0} (Table 5-1, Reaction 1). In addition to the organic reactions, a number of inorganic reactions occur during the corrosion of Fe^{+0}. Chemical reduction can lead to the precipitation of reduced mineral phases such as sulfides (e.g. Reaction 2). Because of the slow abiotic rate of sulfate reduction, the formation of sulfide minerals is not likely to be significant unless the reaction is catalyzed by sulfate-reducing bacteria.

The corrosion process causes an increase in pH as dissolved O_2 (Reaction 3) and water (Reaction 4) are reduced. Hydrogen is generated and may form a separate gas phase (Reaction 4). Fe^{+2} is released during the corrosion of Fe^{+0} (Reaction 1, 3 and 4) and by the dehalogenation of chlorinated VOCs (Section 5.0). The Fe^{+2} may remain in solution or be precipitated by reactions with carbonate, sulfide, or hydroxyl. The pH of Fe^{+0} in PeRT walls at other sites and in laboratory experiments is usually elevated over 9, and often to over 10. The elevated pH causes carbonate minerals to precipitate (Reactions 5 and 6). Hydroxyl ions can combine with Fe^{+2} to form ferrous hydroxide minerals (Reaction 7). If conditions are sufficiently oxidizing, ferric hydroxides similar to common rust will form (Reaction 8).

5.3 NATURAL ATTENUATION

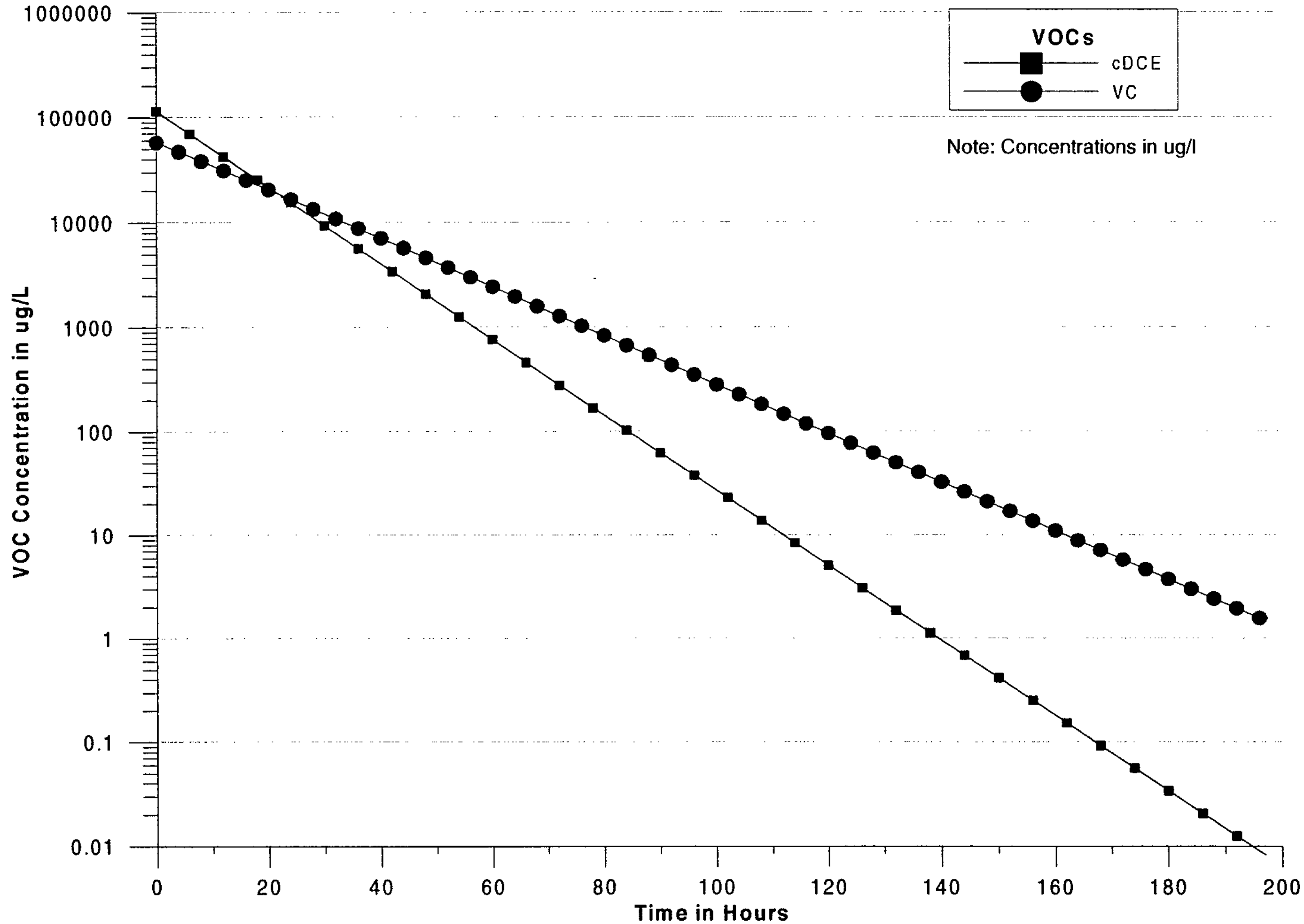
It should be noted that a similar mechanism for chlorinated VOC destruction has been shown as for Natural Attenuation by Reductive Dehalogenation (AFCEE, 1996):



The AFCEE Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (AFCEE, 1996) states that tetrachloroethene is most susceptible to reductive dechlorination because it is the most oxidized. Conversely, vinyl chloride is the least susceptible to reductive dechlorination because it is the least oxidized. This is believed to explain situations where an increase in vinyl chloride concentration is observed over time in chlorinated solvent plumes.

TABLE 5-1
INORGANIC REACTIONS THAT OCCUR IN GROUNDWATER CONTACTING FE^{+0}

Number	Reaction
1	$Fe^0 = Fe^{2+} + 2e^-$
2	$Fe^{2+} + SO_4^{2-} = FeS + 2O_2$
3	$Fe^0 + 2H^+ + 1/2\ O_2 = Fe^{2+} + H_2O$
4	$Fe^0 + 2H^+ = Fe^{2+} + H_2$
5	$Ca^{2+} + HCO_3^- = CaCO_3 + H^+$
6	$Fe^{2+} + HCO_3^- = FeCO_3 + H^+$
7	$Fe^{2+} + 2H_2O = Fe(OH)_2 + 2H^+$
8	$4Fe(OH)_2 + 2H_2O + O_2 = 4Fe(OH)_3$



Rust Environment & Infrastructure

FIGURE 5-1

Plot of Theoretical Concentration Reduction over Time

Cape Canaveral Air Station, Florida

6.0 APPROACHES

This section provides details regarding the approaches used to install the mandrel and JAG walls as well as the basis for the conceptual groundwater pump and treatment system used as a cost comparison for the treatment technologies.

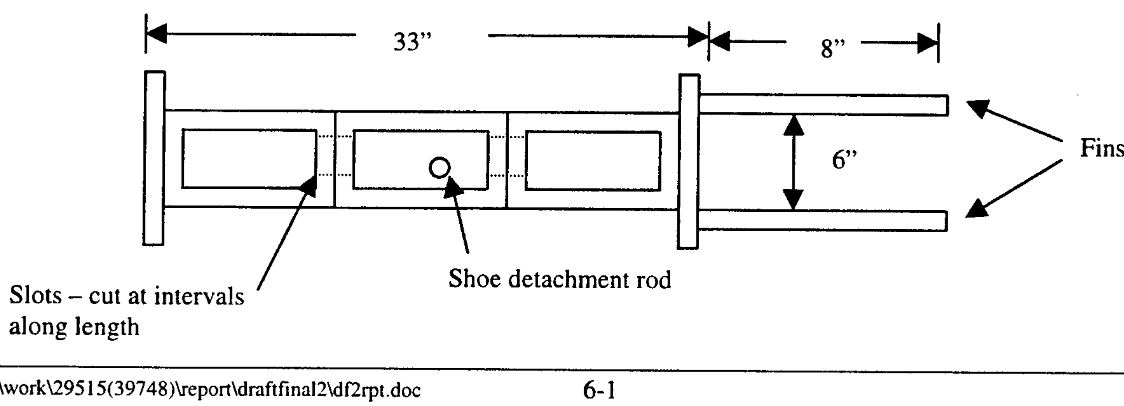
6.1 MANDREL

The mandrel wall segments were located as shown on Figure 4-1. The wall segments were placed in series, beginning at the southern end of the wall. The most up-gradient wall is 51 ½ feet in length along the ground surface. The second and third walls are respectively 12-feet, 1-inch and 11-feet, 11-inches long and are each located 4 feet down-gradient from the preceding wall segment. All the wall segments are 45 feet deep (extending from approximately 1–foot bls to a depth of 45-feet bls) and are 4 inches thick in the direction of groundwater flow.

6.1.1 Description of Equipment

The mandrel used in this project was adapted from the construction industry mandrels used to install wick drains. SSI of Gary, Indiana installed the pilot scale mandrel walls. SSI fabricated the mandrel from three sections of square steel tubing. The inside dimension (where iron is placed) is a panel of approximately 30-inches by 4 inches. Slots were cut through the interior sections of the square steel beams at intervals along the bottom 12 feet to allow iron to flow between the internal tubing sections. The outside footprint of the mandrel is approximately 33-inches by 6-inches. The total length of the fabricated mandrel was approximately 60 feet. Eight inch fins were welded near the bottom of the mandrel along one edge for alignment of the beam with the previous driven section:

PLAN VIEW



The beam was fitted with detachable driving shoes that were fitted to the bottom (leading edge) of the beam. These shoes prevented soil from filling the void spaces in the beam as the beam was driven into place with a 22-ton hammer. A rod in the center tubing section was used to knock the shoe loose. Once at depth, iron was poured into the hollow tubing sections and the shoe was knocked loose of the beam. The shoes remain in place beneath the installed iron. The major equipment was as follows:

- 180-Ton Crane with 80 foot boom to guide mandrel
- 120-Foot guide lead for hammer
- 140-Ton Crane to assist with insertion and extraction
- 22-Ton hammer, driven by 4-75 Hp electric motors
- Electricity provided by a 500 kw, 480 V Caterpillar Generator
- 60-foot long, 7 ton mandrel
- Hopper with chute for iron
- 32 detachable shoes

6.1.2 Operations

Iron was purchased from Peerless Metal Powders & Abrasives in Detroit, Michigan. Approximately 98 tons of Peerless Cast Iron Aggregate 8/50 (100% passing a U.S. Standard No. 8 sieve and 90% to 100% retained on a U.S. Standard No. 50 sieve) were emplaced in the 3 wall segments in 9 days. Iron was delivered in 3,000 pound bags, strapped to palates. The Base provided a forklift and operator to unload the iron.

The large crane was delivered on 6 trailers and required a crew of 14 to assemble in one day. The mandrel guide leads and ancillary equipment arrived on 4 trailers and required 4 days (including weather delays) for a crew of five to assemble. The small crane was delivered assembled.

Installation began at the northern most end of the up-gradient wall. Figure 6-1 shows the layout of individual panels. Panels were overlapped a nominal 4-inches to ensure a continuous treatment zone. To install iron in each panel, the following sequence was used:

1. Position bottom of mandrel over location
2. Hammer on bottom shoe
3. Use 4-foot level to determine vertical and horizontal alignment
4. Reposition mandrel as necessary to achieve straight vertical and horizontal alignment
5. Drive mandrel to depth (checking level during drive)
6. Pour in 1 bag of iron
7. Knock off shoe with pneumatic pump
8. Vibrate beam to settle the first bag of iron
9. Pull out slowly while vibrating (checked iron drop in mandrel first few panels)
10. Pour in second bag of iron
11. Continue to extract mandrel while vibrating
12. Add additional iron if needed
13. Fully extract mandrel
14. Visually inspect iron pattern at surface for continuity and orientation

The up-gradient wall segment is made up of 22 overlapped panels. The final measured length was 51-feet, 6-inches. The second wall segment was installed 4-feet down-gradient of the first. It was made up of 5 panels and measured 12-feet, 1-inches long. The third wall segment was installed 3-feet 8-inches down-gradient of the second and 7-feet, 8-inches down-gradient of the first. It was made up of 5 panels and measured 11-feet, 11-inches long.

During the installation, noise of 92 to 95 decibels were measured at a distance of approximately 100 feet away outside the south door of the nearest building. Inside the building, the maximum noise detected was 67 decibels. Vibrations were noted by workers in the same building, and to a lesser extent up to 200 feet away, but no structural damage was observed.

A Foxboro OVA was used to monitor VOC emissions. VOC emissions were not detected above background concentrations during this installation.

Prior to installation, it was not known if the installation technique would create a wall 4-inches wide (the inside dimensions of the mandrel), or if the width would be wider (up to the outside dimension of 6-inches). A field check of iron density (prior to placement) indicated that the as-received iron density was

151.5 lb/ft^3 and specific gravity was 2.52. A total of 65 bags (98 tons) of iron were installed in 32 panels, for an average of 2 bags (3 tons) of iron in each panel. The inside void space for iron was 4-inches wide. The total depth of the installation was from approximately 1-foot bls to 45-feet bls (44 feet total) over a total length of 75 feet, 6 inches for all three wall segments. This results in a theoretical volume of 1,107 cubic feet. Dividing the total weight of 98 tons by the theoretical volume results in an installed iron density of 177 lb/ft^3. Personnel from Peerless Metals and Abrasives, Inc., stated that this iron has a density of approximately 180 lb/ft^3 when subjected to a moderate tamp. The similarity of the calculated density of 177 lb/ft^3 to the expected value indicates that the iron is probably installed at a 4-inch thickness.

During installation, both horizontal and vertical deviations were measured. When detected prior to driving, the mandrel was adjusted to remove the deviation. The deviations that occurred were as a result of the beam traveling during the installation. Table 6-1 presents a listing of deviations that were not corrected prior to installation.

Installation of 2-inch monitoring wells within the wall was attempted in Panels 12, 27 and 32. In Panel 12, a 7-foot long galvanized steel riser was welded to the inside shoe of the center steel tube section. The well screen, a 20-foot long section of Number 10 slot galvanized pipe, was attached to the bottom riser. This was topped with approximately 18-foot length of solid galvanized steel riser to reach ground surface. Centralizers were welded to the riser so that the well would remain in the center of the iron when the beam was extracted. The plan was to drive the well in with the beam, detach the shoe leaving the well in place, and pour the iron around the well. When the beam was extracted, the well was not visible. A 5-foot deep hole was dug to look for the well but nothing was found. Several mechanisms were considered possible causes for the failure of the well:

- The centralizers may have hung on the slots cut into the beam to allow iron to flow through. This may have pulled the jointed sections of the well apart as the mandrel was withdrawn. The pipe sections could then have dropped back into the iron due to the vibrations. Based on this possibility, the centralizers were only installed on the up-gradient side of the wells installed in Panels 27 and 32.
- The well had been placed in the center steel tube with the rod that drives off the shoe. The rod may have played a role in breaking the well. Subsequent panels were installed in the southern-most steel tube to address this possibility.

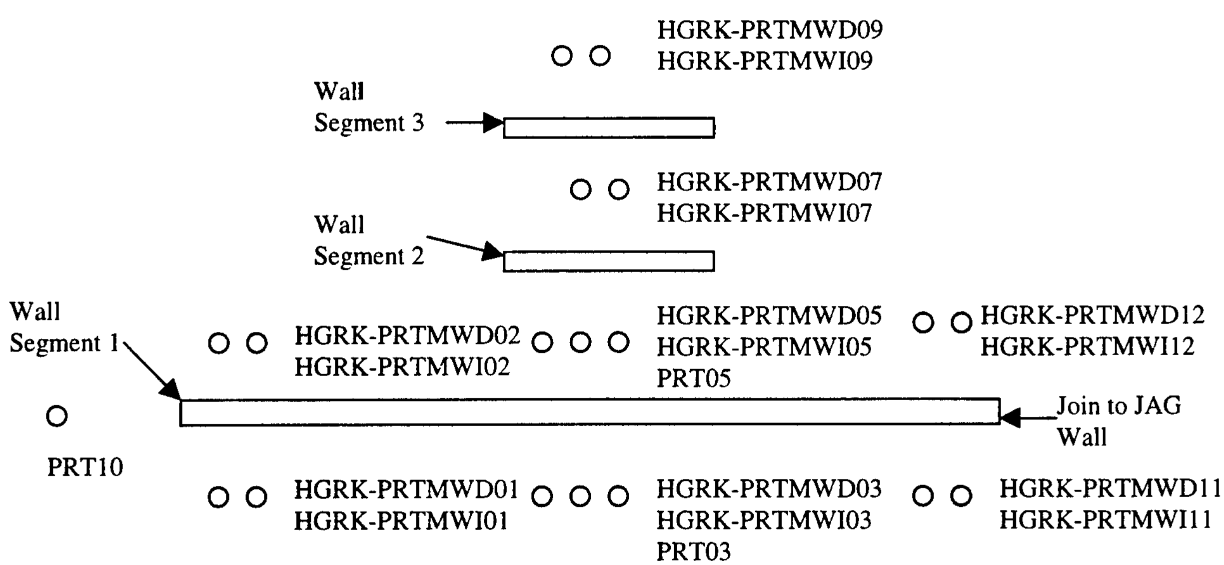
- The wire-wrapped screen may not have been rigid or strong enough to withstand the force of the iron as it was poured, or the vibrations during withdrawal of the beam. A change was made for wells installed in Panels 27 and 32. A PVC screen was threaded onto the bottom 7-foot riser, and solid PVC casing was used above the PVC screen.

Installation of a well in Panel 27 was attempted using a 7-foot riser welded to the shoe. A 20-foot long threaded PVC screen was attached to this riser and a solid PVC riser was attached to the PVC screen. When the beam was removed following installation of the iron, the top PVC riser portion was in the steel tubing. It fell to the ground as the beam was withdrawn so it was not possible to see what, if anything, it had become attached to inside of the steel tube. Although the riser had been securely threaded into the screen section, the male threads at the end of the riser did not appear to be damaged. The failure could have occurred by cracking of the female portion of the joint that remained below grade.

Installation of a well in panel 32 was attempted using the same procedure as in Panel 27. This time, the entire well pulled loose of the weld at the shoe and remained stuck inside the beam.

6.1.3 Monitoring Results

Monitor well construction and installation is discussed in Section 4.2. Monitoring wells and in-situ flow sensors were laid out as follows:



The prefix "HGRK-PRTMWD" indicates a "deep" (screened from 35 to 40 feet bls) monitoring well. The prefix "HGRK-PRTMWI" indicates an "intermediate (screened from 15 to 20 feet bls) monitoring well. The prefix "PRT" indicates an in-situ flow sensor installed at approximately 40 feet bls. Samples from the intermediate wells were collected twice (February and August 1998) during the pilot test and analyzed for VOCs. Samples from the deep wells were collected quarterly (February, May, August and November 1998) for analysis of VOCs. The results are presented in Appendix C. Figure 6-2 shows the decrease or increase in VOC concentrations across the wall segments for samples collected in the intermediate wells. Figure 6-3 presents the decrease or increase in VOC concentrations across the wall segments for samples collected in the deep wells. On each sheet of these figures, the percent reduction or increase is calculated for pairs of wells as follows:

$$\frac{100\% \times (\text{up-gradient concentration minus down-gradient concentration})}{\text{up-gradient concentration}}$$

The results are averaged for the mandrel and JAG walls individually.

There are limitations in this approach which make true quantitative comparisons impractical. Some of these limitations are as follows:

1. This approach assumes that the groundwater flow directions is squarely perpendicular to the wall in all locations. As discussed in Section 4, the direction of groundwater flow at any given well pair location is variable and not squarely perpendicular to the wall.
2. The upgradient concentrations were not uniform along the length of the wall or over time. Thus, it is not known exactly what upgradient concentration would be representative for the concentrations measured downgradient.
3. Since groundwater flow is not squarely perpendicular to the wall, there is a possibility that the concentrations reflect a mixture of water that has been treated with groundwater that has not passed through the treatment zone. The well pairs considered least likely to be influenced by mixing are the centrally located wells along the main wall. These are wells HGRK-PRTMWD11, I11, D12 and I12 for the mandrel wall.

While the limitations discussed above make exact quantitative comparison suspect, the evaluation is useful to determine general trends. The percent reduction results calculated for the average in all wells and for the centrally located well pair in the intermediate zone are as follows:

INTERMEDIATE WELL VOC RESULTS			
Parameter	**Sampling Event**	**Average % Reduction or Increase across the wall segments**	**Center Wells % Reduction or Increase across the main wall segment**
Vinyl Chloride	February 1998	-1558% (increase)	-833% (increase)
	August 1998	+ 0% (no change)	+ 0% (no change)
trans-1,2 Dichloroethene	February 1998	+15% (decrease)	+32% (decrease)
	August 1998	+ 0% (no change)	+ 0% (no change)
cis-1,2 Dichloroethene	February 1998	-2932% (increase)	-986% (increase)
	August 1998	-54% (increase)	+81% (decrease)
1,1-Dichloroethene	February 1998	+ 0% (no change)	+ 0% (no change)
	August 1998	+ 0% (no change)	+ 0% (no change)

The +0% values are representative of situations where both the up-gradient and down-gradient concentrations were less than detection.

For the February 1998 results in the intermediate wells, it appears that the concentrations of vinyl chloride and c-DCE increase as the groundwater moves through the wall segments. The concentration of t-DCE generally decreases as the groundwater flows through the wall segments. Concentrations of DCE did not exceed detection levels either up-gradient or down-gradient.

For the August 1998 results in the intermediate wells, the concentrations of vinyl chloride, t-DCE and DCE did not exceed detection levels either up-gradient or down-gradient. For the average results, the concentration of c-DCE appeared to increase as the groundwater moved through the wall. However, the analytical results for the centrally located pair indicates that the concentration decreases.

The percent reduction results for the average in all wells and for the centrally located well pair in the deep zone are as follows:

DEEP WELL VOC RESULTS			
Parameter	**Sampling Event**	**Average % Reduction or Increase across the wall segments**	**Center Wells % Reduction or Increase across the main wall segment**
Vinyl Chloride	February 1998	-150% (increase)	+51% (decrease)
	May 1998	-13% (increase)	-6% (increase)
	August 1998	-38% (increase)	-123% (increase)
	November 1998	-10% (increase)	-51% (increase)
trans-1,2 Dichloroethene	February 1998	-22% (increase)	+89% (decrease)
	May 1998	+20% (decrease)	+74% (decrease)
	August 1998	+3% (decrease)	+89% (decrease)
	November 1998	+0% (no change)	+66% (decrease)
cis-1,2 Dichloroethene	February 1998	-22% (increase)	-16% (increase)
	May 1998	+6% (decrease)	+66% (decrease)
	August 1998	+7% (decrease)	+84% (decrease)
	November 1998	+9% (decrease)	+98% (decrease)
1,1-Dichloroethene	February 1998	+ 18% (decrease)	+ 52% (decrease)
	May 1998	+ 0% (no change)	+ 0% (no change)
	August 1998	+45% (decrease)	+62% (decrease)
	November 1998	+15% (decrease)	+0% (no change)

The +0% values are representative of situations where both the up-gradient and down-gradient concentrations were less than detection.

In February, the average concentrations of vinyl chloride, t-DCE, and c-DCE appear to increase as groundwater moves through the wall. The concentration of DCE appears to decrease. The results for the centrally located well pair indicates somewhat different results; a decrease in concentration of vinyl chloride, t-DCE and DCE and an increase in concentration of c-DCE as the groundwater moves through the wall.

In May, August and November, the results of the average concentrations and center well concentrations show the same general trends: an increase in vinyl chloride, and a decrease in t-DCE, c-DCE and DCE as groundwater moves through the wall. DCE was not present above detection levels so comparison was not possible in May.

The trends noted for May, August and November in the deep zone of the uppermost aquifer seem consistent. It seems reasonable to disregard the February 1998 results, as these were the first samples

collected and groundwater collected from the down-gradient wells may not have passed through the treatment wall. In general, it appears that as groundwater flows through the mandrel wall segments, the concentrations of c-DCE, t-DCE and DCE decrease while the concentration of vinyl chloride increases.

The monitoring results collected during the first year of operation were insufficient to determine the effectiveness of the PeRT walls on groundwater restoration. Two of the reasons for inconclusive results include the slow rate of groundwater flow and the high variability of the influent chlorinated VOC concentrations. During installation of the monitoring wells, it was noted that the soils at 35 to 40 feet bls in this area are silty to clayey sands. High OVA readings (between 100 and 300 ppm) were noted on soil samples from these depth intervals. It is therefore likely that the chlorinated solvents at this depth are adsorbed onto the soils. As treated water flows through a wall segment, it could be flushing additional chlorinated VOCs from the soil down-gradient of the wall. With the slow rate of groundwater flow in the area, this could continue for a prolonged period of time. Therefore, additional monitoring is recommended to determine if further degradation of the chlorinated VOCs occur with time.

6.1.4 Lessons Learned

The mandrel was fabricated to install a wall to a total depth of 60 feet bls. If the mandrel had been fabricated to install a wall to only 45 feet (the depth needed on this project), smaller equipment could have been used to hold and drive the mandrel. This could have resulted in both cost savings and potentially lower noise and vibration levels during the installation.

Initial alignment of the mandrel over the wall was time consuming. A guide at ground surface might make initial alignment easier. Once aligned, the beam stayed true when driven to depth. Based on this pilot study, this method of installation should be appropriate for depths of 60 feet or greater. More precise alignment and measuring/tracking tools should be used to ensure that the wall is within tolerance limits for deeper installations.

There were several unknowns in estimating the quantity of iron required for installation. A range of bulk iron densities were provided, but is was not known to what degree the iron would compact during the installation process and to what degree the soil would rebound and fill the void space as the mandrel was removed. The mandrel created a 6-inch wide opening on the outside to allow a 4-inch opening for iron.

The lead-time for delivery of iron was long – minimum of 1 week after order, 2 weeks preferred. As stand-by costs for equipment and crews were high, a conservatively high quantity of iron was ordered and there was left over iron to return. This probability had been foreseen, and arrangements had been made with the supplier to take the iron back. There were costs associated with shipping the iron both ways and a restocking charge by the supplier. The in-place density is now known, and more accurate estimates could be made for quantity of iron required.

Visual observations indicated that some degree of subsidence may have occurred in an area as large as 50 feet by 10 feet. The maximum depression in this area was estimated to be approximately 6 to 8 inches and occurred at the insertion point.

6.1.5 Costs

Estimated costs associated with the mandrel wall installation are presented in Table 6-2. Excluding mobilization, the total installed cost for the mandrel wall was $232,712. Based on installing 75.5 linear feet, the cost per linear foot installed was $3,082 per linear foot. The total installed cost including mobilization was $307,712. When mobilization is included, this cost rises to $4,076 per linear foot.

6.2 JET ASSISTED GROUTING

The JAG wall segments were located as shown on Figure 4-1. Prior to installing the pilot test wall segments, mix ratios and jet pressures were optimized in a test area. Iron was emplaced as slurry, mixed with guar gum and a binder.

6.2.1 Description of Equipment

The JAG wall segments were installed by Geocisa/Geobase, under contract to Foremost Solutions. This installation technique required injection of high viscosity iron slurry. The slurry was made from mixing iron, guar gum, an enzyme and borax.

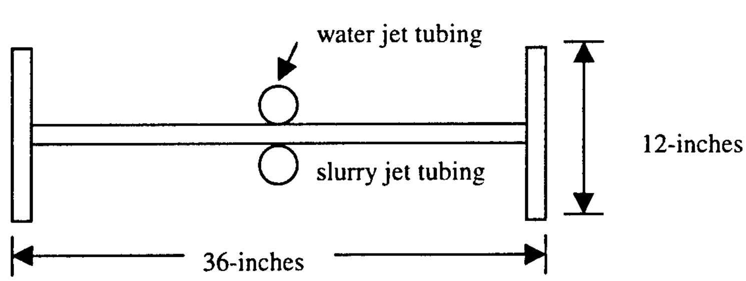
The guar gum was Hercules Supercol™ food grade fine (200-mesh size) powder. It was mixed with water in 120-gallon batches in a stirred open top tank to form 2 to 3% solutions. The guar solution was

pumped first to a holding tank, then into a truck-mounted batch mixing plant. The feed rate of guar gum was controlled by a positive displacement pump that discharged into an auger screw mixer. Iron filings were poured from the 3000-pound bags into the top of the batch mixing plant. The iron filings were added to the screw auger mixer using an aggregate belt feed with adjustable height screeds and variable speed control. In addition, an enzyme and a thickener were added with a metering pump. The screw mixer discharged into a grout pump hopper. The grout pump hopper fed a diesel powered grout pump with two 4-inch diameter swing-tube cylinders. The discharge was to hoses that fed the down-hole injection equipment. The quantity of slurry pumped down-hole was measured by counting the number of strokes of the pump. The rate of pumping was constant so the amount of iron emplaced was controlled by the speed at which the beam was withdrawn.

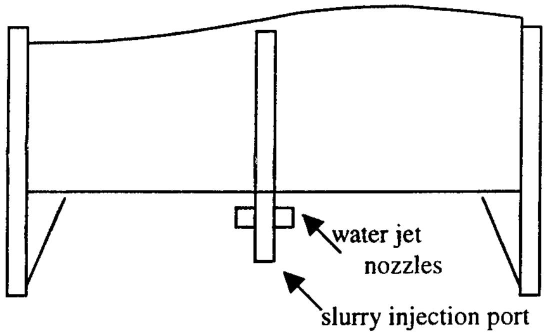
Initially, a 3% guar solution was used. This tended to bridge in the lines to the down-hole injection equipment. The solution was diluted to 2% guar gum in water, and borax was used as a thickener. The enzyme (Liquid Cellulose, Gencor Product Code A03107G121) was mixed with water at a ratio of 1-quart of enzyme to 25-gallons of water. Borax was added and the enzyme solution was added to the guar gum and iron slurry at a rate of 0.6 to 0.7 gpm. Table 6-3 presents the concentration of guar and quantity of borax added for each panel installed.

The down-hole injection equipment used to install the wall segments consisted of a 36-inch by 12-inch wide-flange steel beam, 48-foot long, 1-inch thick, with tubing welded to the web for water and iron slurry injection:

PLAN VIEW



SECTION VIEW AT BOTTOM



A guide on the ground in the line of the wall was fabricated from steel I-beams to assist in alignment and location of each panel installed. This guide was laid along the ground surface during panel installation. Water was jetted during driving to open a channel under the beam. The water jet assembly was attached to the leading edge of the beam web, with nozzles oriented horizontally to direct spray at the inside surfaces of the flanges at either end. During driving, water was injected at flows of up to 20-gpm and 6,000-psi pressure. The iron-slurry injection tubing was fitted with a bottom plug. A short steel rod was used to knock the plug free when the beam was at depth.

6.2.2 Operations

Iron was delivered in 3,000-pound bags, strapped to palates. The Base provided a forklift and operator to unload the iron. Iron was purchased from Peerless Metal Powders & Abrasives in Detroit, Michigan. Approximately 107 tons of Peerless Cast Iron Aggregate P1 (100% passing a Standard No. -16 sieve to dust) was used in the 3 wall segments in 24 days. Approximately 93 tons of iron was injected in the pilot test area. Approximately 24 tons of an iron/soil mixture was subsequently disposed as spoils, resulting in an estimated 83 tons emplaced.

The crane used in this installation was delivered assembled. The JAG equipment was delivered on 3 trucks and required 5 days to assemble.

In order to determine the amount of slurry that would need to be injected into each panel, a test was performed in an area to the south of the parking lot. Three panels were installed. A backhoe was then used to excavate down to the top of the panels so that the installed thickness could be observed.

As the beam had a high potential to deflect as it was driven to depth, the first and third test panels were installed prior to the second. This equalized the forces at either flange end of the beam during installation (either slurry would not be present at either end or it would be present at both ends). Approximately 1 cubic foot (cf) of slurry was injected per linear foot of depth, for a total of 41 cf of slurry in test panel number 1 and 46 cf of slurry in test panel number 3. In test panel number 2, approximately 1.4 cf of slurry was injected per linear foot of depth, for a total of 58 cf of slurry.

Following installation of the test panels, overburden soil was excavated to visually observe the installation patterns. Test panel 1 was approximately 1.5-inches thick, and bulged in the center where the slurry was injected. The area cut by the flanges also filled with slurry. Test panel number 3 was approximately 1-inch thick on the end furthest from test panel 2, and bulged in the middle. Test panel number 2 was approximately 3 to 4 inches thick.

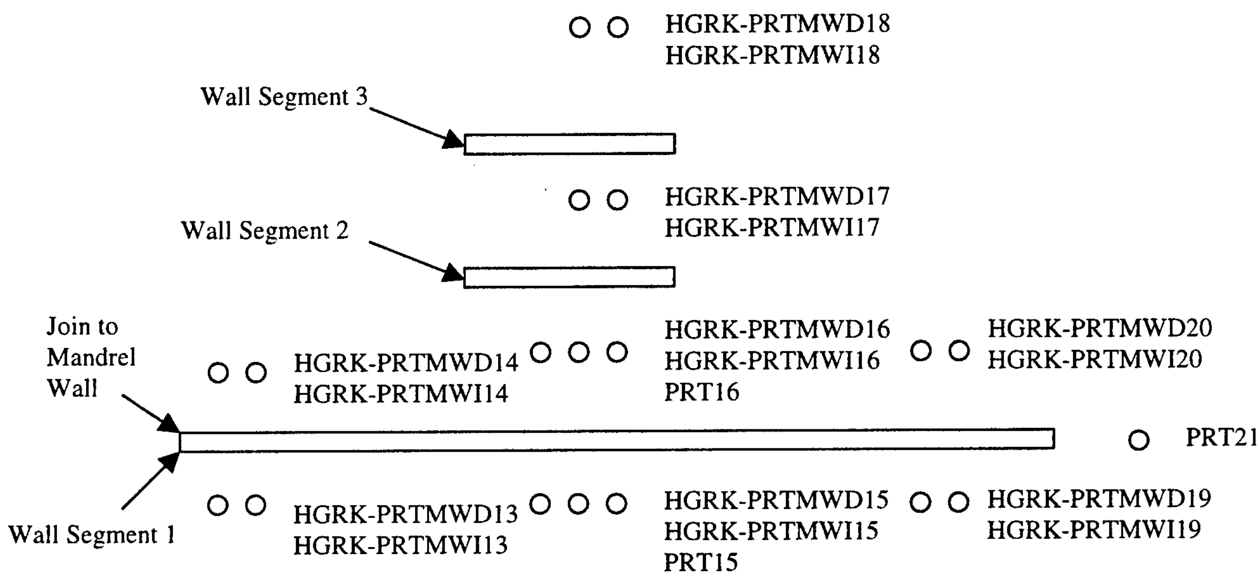
Based on this testing, the quantity of iron needed to create a 4-inch thick wall was estimated to be 8,400 pounds of iron (approximately 60 cf of slurry) per panel during installation of the pilot scale JAG walls. Table 6-3 presents the actual amount of slurry injected during installation of each panel. Note that the total volume injected does not equal the total volume placed, as an estimated 2 to 5 cf of slurry per panel became spoil due to the excess coming to the surface and the residuals in the pumping lines. The volumes of slurry injected ranged from 46.4 to 65.4 cf of slurry. It is believed that the panels are thicker at the bottom than at the top. The rate of slurry placement was determined by the speed at which the beam was withdrawn (pumping rate being constant). The slurry would break out of the surface prior to fully withdrawing the beam (see Table 6-3 for depth at which slurry broke out for each panel). After a break out of slurry was noticed, the beam was withdrawn at a faster rate, thus less iron was installed from the point of breakout to surface.

Installation of the 3 pilot test wall segments began on the longest (up-gradient) wall segment and proceeded generally from South (adjoining the mandrel wall segment) to North. As in the test area, beams were installed by skipping and returning to locations so that for each beam installed the forces on either side would be equal (either no slurry on either side or slurry on both sides). Figure 6-4 shows the layout and the sequence of installation for the individual panels.

During installation, deviations were measured with a 4-foot level. Table 6-4 presents the amount of deviation measured in each panel. On several occasions, the beam was driven then withdrawn and reinserted to attempt to bring the deviation to tolerance.

6.2.3 Monitoring Results

Monitor well construction and installation is discussed in Section 4.2. Monitoring wells were laid out as follows along the JAG walls:



The prefix "HGRK-PRTMWD" indicates a "deep" (screened from 35 to 40 feet bls) monitoring well. The prefix "HGRK-PRTMWI" indicates an "intermediate (screened from 15 to 20 feet bls) monitoring well. The prefix "PRT" indicates an in-situ flow sensor installed at approximately 40 feet bls.

Samples from the intermediate wells were collected twice (February 1998 and August 1998) during the pilot test and analyzed for VOCs. Samples from the deep wells were collected quarterly for analysis of VOCs. The results are presented in Appendix C. Figure 6-2 shows the decrease or increase in VOC concentrations across the wall segments for samples collected in the intermediate wells. Figure 6-3 presents the decrease or increase in VOC concentrations across the wall segments for samples collected in the deep wells. On each sheet of these figures, the percent reduction or increase is calculated for pairs of wells as follows:

$$\frac{100\% \times (\text{up-gradient concentration minus down-gradient concentration})}{\text{Up-gradient concentration}}$$

The results are averaged for the mandrel and JAG walls individually.

There are limitations in this approach which make true quantitative comparisons impractical. Some of these limitations are as follows:

1. This approach assumes that the groundwater flow directions is squarely perpendicular to the wall in all locations. As discussed in Section 4, the direction of groundwater flow at any given well pair location is variable and not squarely perpendicular to the wall.
2. The upgradient concentrations were not uniform along the length of the wall or over time. Thus, it is not known exactly what upgradient concentration would be representative for the concentrations measured downgradient.
3. Since groundwater flow is not squarely perpendicular to the wall, there is a possibility that the concentrations reflect a mixture of water that has been treated with groundwater that has not passed through the treatment zone. The well pairs considered least likely to be influenced by mixing are the centrally located wells along the main wall.

While the limitations discussed above make exact quantitative comparison suspect, the evaluation is useful to determine general trends. These are wells HGRK-PRTMWD13, I13, D14 and I14 for the JAG wall. The percent reduction results for the average in all wells and for the centrally located well pair are as follows:

INTERMEDIATE WELLS VOC RESULTS			
Parameter	**Sampling Event**	**Average % Reduction or Increase across the wall segments**	**Center Wells % Reduction or Increase across the main wall segment**
Vinyl Chloride	February 1998	-1796% (increase)	-8300% (increase)
	August 1998	-586% (increase)	-253% (increase)
trans-1,2 Dichloroethene	February 1998	-104% (increase)	-11% (increase)
	August 1998	+ 8% (decrease)	+ 64% (decrease)
cis-1,2 Dichloroethene	February 1998	-429% (increase)	-1463% (increase)
	August 1998	-109% (increase)	+57% (decrease)
1,1-Dichloroethene	February 1998	+ 0% (no change)	+ 0% (no change)
	August 1998	+ 0% (no change)	+ 0% (no change)

The +0% values are representative of situations where both the up-gradient and down-gradient contaminant concentrations were less than detection.

In February, concentrations of vinyl chloride, t-DCE and c-DCE appear to increase as groundwater moves through the wall segments. DCE was not present in detectable concentrations either up-gradient or down-gradient.

In August, the average concentrations of vinyl chloride and c-DCE appear to increase as groundwater moves through the wall. The concentration of c-DCE in the center well pair appears to decrease. Concentrations of t-DCE appear to decrease as groundwater moves through the wall for both the average and center well results. DCE was not present in detectable concentrations either up-gradient or down-gradient.

DEEP WELLS VOC RESULTS			
Parameter	**Sampling Event**	**Average % Reduction or Increase across the wall segments**	**Center Wells % Reduction or Increase across the main wall segment**
Vinyl Chloride	February 1998	-484% (increase)	-31% (increase)
	May 1998	-41% (increase)	-54% (increase)
	August 1998	-110% (increase)	-155% (increase)
	November 1998	-40% (increase)	-140% (increase)
trans-1,2 Dichloroethene	February 1998	+13% (decrease)	+61% (decrease)
	May 1998	+20% (decrease)	+55% (decrease)
	August 1998	+20% (decrease)	+59% (decrease)
	November 1998	+17% (decrease)	+22% (decrease)
cis-1,2 Dichloroethene	February 1998	-316% (increase)	+20% (decrease)
	May 1998	+26% (decrease)	+66% (decrease)
	August 1998	+15% (decrease)	+78% (decrease)
	November 1998	-8% (increase)	+22% (decrease)
1,1-Dichloroethene	February 1998	+ 18% (decrease)	+ 56% (decrease)
	May 1998	+ 0% (no change)	+ 0% (no change)
	August 1998	+37% (decrease)	+88% (decrease)
	November 1998	+17% (decrease)	+35% (decrease)

The +0% values are representative of situations where both the up-gradient and down-gradient contaminant concentrations were less than detection.

In February, average concentrations of vinyl chloride and c-DCE appear to increase as groundwater moves through the wall segments. For the center well pair, vinyl chloride appears to increase and c-DCE appears to decrease. For both the average and center well pair, concentrations of t-DCE and DCE appear to decrease.

In May, the trends are consistent for the average and center well pair: The concentrations of vinyl chloride increases and the concentrations of t-DCE and c-DCE decrease. DCE was not present in detectable concentrations either up-gradient or down-gradient.

In August, the trends are consistent for the average and center well pair: The concentrations of vinyl chloride increases and the concentrations of t-DCE, c-DCE and DCE decrease.

In November, there is a possible deviation from the trends noticed in May and August; the average c-DCE concentration appears to increase as groundwater flows through the wall. The concentration of c-DCE in the center wells follows the previous trend and decreases as groundwater flows through the wall.

The general trends noted for May, August and November in the deep zone of the uppermost aquifer seem consistent. It seems reasonable to disregard the February 1998 results, as these were the first samples collected and groundwater collected from the down-gradient wells may not have passed through the treatment wall. In general, it appears that the JAG wall segments decrease the concentrations of c-DCE, t-DCE and DCE but increase the concentration of vinyl chloride.

The monitoring results collected during the first year of operation were insufficient to determine the effectiveness of the PeRT walls on groundwater restoration. Two of the reasons for inconclusive results include the slow rate of groundwater flow and the high variability of the influent chlorinated VOC concentrations. During installation of the monitoring wells, it was noted that the soils at 35 to 40 feet bls in this area are silty to clayey sands. High OVA readings (between 100 and 300 ppm) were noted on soil samples from these depth intervals. It is therefore likely that the chlorinated solvents at this depth are adsorbed onto the soils. As treated water flows through a wall segment, it could be flushing additional chlorinated VOCs from the soil down-gradient of the wall. With the slow rate of groundwater flow in the area, this could continue for a prolonged period of time. Therefore, additional monitoring is recommended to determine if further degradation of the chlorinated VOCs occur with time.

6.2.4 Lessons Learned

There were two injuries requiring medical treatment during the JAG wall installation. The first injury occurred when iron was being poured into the batch mixing plant to mix with guar gum for the first pilot scale PeRT wall panel installed (Panel number 2). Fine iron dust blew outside of the loading area into the eye of an observer at the site. Following this incident, safety goggles were required whenever the dry iron was handled.

The second injury was related to the high-pressure water hose. After the beam had been driven to depth and the bottom plug knocked out, the slurry jet tubing filled with sand. The crew used a high-pressure water line to free the clog. A high-pressure water hose was run down into the clogged slurry jet tubing, without the water running. The high-pressure water hose became clogged as well. When the water was turned on, the clog was noticed. The crew began pulling up the water line, with the line under pressure. When the hose reached the surface, the clog broke free. The decrease in line pressure caused the hose to whip around, breaking the wrist and cutting the forearm of a crewmember. Following the incident, the slurry injection tube was filled with water prior to knocking the plug off so that sand would not fill in the tube. The accident could also have been avoided with strict adherence to safety procedures when using high-pressure hoses (bleed pressure before handling).

The beam had a high potential to deflect as it was driven. Although several different hammers and driving speeds were utilized, the difficulty persisted. It may be a function of the geometry of the beam used in this installation method or the absence of leads to guide the hammer. For the depth and thickness of wall in this pilot test, a ½-inch deviation over 4 feet was considered acceptable. It was difficult to achieve this precision, and deeper installations would be even more difficult to keep within tolerances.

During installation, the slurry was injected as the beam was withdrawn. Iron slurry would rise to the surface while the beam was still below the water table. The water table was approximately 3 feet below the installation trench. Slurry broke out at depths ranging from 15 to 24 feet bls. When breakout was observed, the beam was withdrawn at a faster rate and consequently less iron was installed in the upper portion of the wall. The highest concentrations of contaminants at this site were below the depths at which this thinning of the wall occurred.

The amount of spoils generated was underestimated so adequate provisions had not been made to collect and separate solids and liquids. Spoils were generated in several ways:

1) Batches of iron/guar mix would harden if not used soon after mixing.
2) Iron and guar mixture would break out at the surface after the slurry was injected.
3) Water was used for cleaning equipment so that the slurry would not set up in pumps, hoses, etc.
4) As solids removed during the driving step.

The largest quantity of spoils (24 tons) was produced by the slurry breaking out of the ground before the beam had been withdrawn the full distance. An estimated 2 to 5 cubic feet of iron spoil was generated at each beam. Since this slurry had been in contact with contaminated groundwater, it was containerized sampled and disposed in accordance with Base IDW practices.

An unmeasured quantity of slurry was also lost prior to injection into the ground. After the subcontractor had demobilized the mixing equipment, numerous small clumps of iron were found in the vicinity. These were found in the area of the parking lot where mixing had been performed and were scraped up prior to resurfacing the parking lot. Even so, small flakes of iron remained and the resurfacing layer of the parking lot in that area chipped off after a few months. Clumps were also found in the grassed area around the parking lot. These were removed by hand excavating and disposed.

Production was slow due to numerous equipment problems. Some of these were related to the difficulty in pumping the abrasive slurry. The iron filings abraded the wear plates in the pump, allowing large clumps to pass through into the injection tubing. These had a tendency to bridge in the hoses to the injection point. There were also problems with the plug in the bottom of the iron injection tubing. As the beam was driven, the force of the soil pushed up on the plug. It was difficult to push out to allow iron to be injected. Additional slow-downs were encountered due to alignment problems. Often, the beam had to be driven more than once due to high deviations from vertical.

6.2.5 Costs

Estimated costs associated with the JAG wall installation are presented in Table 6-5. Excluding mobilization and pre-installation testing, the total installed cost for the JAG wall was $235,639. Based

on installing 64 linear feet, the cost per linear foot installed was $3,682 per linear foot. The total installed cost including mobilization and pre-installation testing was $306,538. When mobilization is included, this cost rises to $4,790 per linear foot.

6.3 GROUNDWATER PUMP AND TREAT

6.3.1 Assumptions

One objective of the pilot study was to compare the cost of the PeRT wall treatment system with a typical groundwater pump and treat system. The basis of comparison was selected to be a groundwater pump and treat system sized such that the length of the capture zone would approximate the 100-foot PeRT wall treatment length. Simple groundwater modeling was performed to estimate the volume of water that would need to be extracted in order to create a 100-foot length capture zone. A discussion of the model assumptions and results is presented in Appendix D. The estimated required extraction rate was 14 gpm.

The primary treatment processes selected were air stripping followed by activated carbon polishing of water and adsorption of the air emissions onto vapor phase carbon. Since vinyl chloride is not readily adsorbed onto carbon, a great deal of carbon will be used for this application. It is quite likely that there are much more economical treatment alternatives for treatment of this water. However, this is considered reliable technology that has been tested often enough to provide an accurate cost estimates without treatability study. This treatment should remove 99% or more of the influent concentrations. Wherever possible, unit rate costs were obtained from actual costs at the Cape Canaveral Air Station. The following presents the basic components of the conceptual groundwater pump and treat system:

- Site Preparation consisting of asphalt removal and trenching for pipes;
- One 4-inch diameter stainless steel extraction well, 15-foot long screened section to achieve a capture zone similar to the 100 linear foot up-gradient wall and a total flow rate of 14 gpm;
- One submersible groundwater pump and controls, all installed sub-grade with explosion proof electrical and controls;
- One well vault with cover, capable of supporting traffic loads;
- Installation of 4 groundwater monitoring wells;

- One air stripper (Delta Vanguard® Model ΔS1-100) with explosion proof electrical, blower motor and controls;
- Calgon Vapor Pac Units for adsorption of stripped VOCs. Each Vapor Pac unit contains 1,800 lbs of carbon. Estimated use of 12 Vapor Pacs over 10 months at worst case conditions;
- Calgon Cyclesorb FP-2 liquid phase GAC units. Each contains 2,000 pounds of carbon and an estimated 17 units will be required for this project;
- Weekly checks of emissions from the first vapor phase carbon cell in series with an OVA;
- Weekly analysis of grab samples from the first liquid phase carbon cell in series for analysis of vinyl chloride;
- Monthly effluent sampling and analysis; and
- Quarterly monitor well sample collection and analysis for VOCs.

A conceptual layout of wells and equipment is shown in Figure 6-5. Table 6-6 presents a cost estimate for the installation, operation and monitoring of the system. The estimate includes costs components that were included for the PeRT wall costs. The period of operation was assumed to be the same as for the PeRT wall pilot study.

6.3.2 Comparison of PeRT Wall to Pump and Treat Cost

Table 6-7 presents a comparison of actual PeRT wall installation and estimated monitoring costs (for both walls) with the estimated cost for groundwater pump and treat over the same time period for the same volume of water collected. The actual monitoring costs during the pilot study were not used in this comparison since the same level of information would not be needed to monitor a remedial action. Instead, monitoring was made consistent with the groundwater "pump and treat" system. The estimated time required for the savings in O&M to off-set the higher capital cost is 4 years. This is considered a conservative estimate since other savings could be realized as well (not installing flow sensors, installing fewer monitoring wells, not installing the downgradient wall sections).

TABLE 6-1
MANDREL INSTALLATION FIELD QUALITY CONTROL

Wall Segment	Panel Number	Date	Horizontal Deviation (inches from wall layout centerline over length of panel) (Note 3)	Vertical Deviation (inches from vertical over 4-feet) (Note 3)
Up-Gradient	1	10/06/1997		
	2	10/06/1997		
	3	10/06/1997	2	
	4	10/07/1997	½ to 1	
	5	10/07/1997		
	6	10/07/1997		
	7	10/07/1997		
	8	10/07-08 /1997	1	½
	9	10/08/1997		
	10	10/08/1997		
	11	10/08/1997		
	12 (Note 1)	10/11/1997		
	13	10/08/1997		
	14	10/08/1997		
	15	10/09/1997		
	16	10/09/1997		
	17	10/09/1997		
	18	10/09/1997		
	19	10/11/1997		
	20	10/11/1997		
	21	10/11/1997		
	22	10/11/1997		
First Down-Gradient	23	10/11/1997		⅛
	24	10/11/1997		
	25	10/14/1997		
	26	10/14/1997		
	27 (Note 2)	10/14/1997		
Second Down-Gradient	28	10/14/1997		
	29	10/14/1997		
	30	10/14/1997		
	31	10/14/1997		
	32 (Note 2)	10/15/1997		

Note 1: Panel 12 was the first location where installation of a well inside the wall was attempted. It was not installed in sequence. Panel 11 was installed and space was left for panel 12. Panels 13 through 18 were installed then Panel 12. This was due to material delivery schedule for the well components.

Note 2: Panels 27 and 32 were the locations in down-gradient walls where well installation was attempted inside the wall.

Note 3: The deviation measurements represent "as installed" values. Deviations that were corrected prior to installation are not noted. If no value is listed, no measurable deviation was noted.

TABLE 6-2
MANDREL INSTALLATION COSTS

SUBCONTRACTOR CHARGES (SSI & PEERLESS)					
Mobilization/Demobilization:					$ 75,000
Installation of PeRT Wall					$154,100
Bonding					$ 4,600
Iron					$ 56,000
SUBTOTAL SUBCONTRACTORS:					**$289,700**
INCIDENTAL COSTS (Based on 21 days elapsed time on site)					
	ITEM	**UNITS**	**$/UNITS**	**NO. UNITS**	**TOTAL $**
Temporary Facilities					
1	Port-O-let	Month	$73.67	0.70	$51.57
2	Barricades	Month	$386.37	0.70	$270.46
	Subtotal				$322.03
Construction Oversight					
3	Phone	Month	$336.37	0.70	$235.46
4	Noise Monitor	Month	$100.00	0.70	$70.00
5	Ford F150	Day	$46.08	21.00	$967.68
6	Explosimeter	Week	79.60	3.00	$238.80
7	Field Oversight	Day	$593	18	$10,674.00
8	Engineering Inspection	Each	$2,500	1	$2,500.00
9	Rust Personnel Unload Iron	Total	$1,500	1	$1,500.00
10	Daily Expenses	Day	$28	18	$504.00
11	Miscellaneous field supplies	Each	$1,000	1	$1,000.00
	Subtotal				$17,689.94
SUBTOTAL INCIDENTALS					**$18,011.96**
TOTAL ESTIMATED INSTALLATION COST					**$307,711.96**

TABLE 6-3
JAG INSTALLATION VARIABLE PARAMETERS

Wall Segment	Panel Number	Order of Installation	% Guar in water	Quantity of Borax[1] (number of boxes	Density (lb iron/ft^3)	Volume Injected[2] (cf)	Depth where iron breaks out at surface (feet)[3]
Up-Gradient	1	3	2.0	1.5	--	55.6	-15
	2	1	3.0	None	--	--	-15
	3	4	2.0	1.5	--	55.8	--
	4	2	2.0	1.5	--	51.8	-17
	5	7	2.0	1	--	46.4	-20
	6	5	2.0	1	--	49.8	-19
	7	8	2.0	⅓	143	65.4	-19
	8	6	2.0	1	147	54.5	-23
	9	11	2.0	⅓	--	57	-16
	10	9	2.0	⅓	154	55.2	-19
	11	12	2.0	⅓	--	44.5	-16
	12	10	2.0	⅓	--	57.8	-18
	13	15	2.0	¼	129	56.5	-17
	14	13	2.0	⅓	--	53.4	-14
	15	16	2.0	¼	156	48	-18
	16	14	2.0	⅓	150	54.9	-15
	17	18	2.0	¼	152	55.2	-21
	18	17	2.0	¼	144	56	-17
First Down-Gradient	19	19	2.0	¼	147	52	-18
	20	21	2.0	¼	153	45	-24
	21	20	2.0	¼	142	51.6	-14
Second Down-Gradient	22	22	2.0	¼	--	51	-18
	23	24	2.0	¼	136	46	-17
	24	23	2.0	¼	--	53	-24

Notes: 1. Each box of Borax contained 76 ounces. The quantities listed are the amount mixed into each 25- gallon batch of enzyme and water mixture.

2. This represents the volume pumped into each panel. Approximately 2 to 5 cubic feet of spoils were created at each panel due to excess slurry rising to the surface.

3. This depth represents the distance from the beam to land surface when iron began rising up from the excavation. From this point upward, the amount injected is smaller.

TABLE 6-4
JAG INSTALLATION FIELD QUALITY CONTROL

Wall Segment	Panel Number	Date	VERTICAL DEVIATION			
			Perpendicular to center line of wall		Parallel to center line of wall	
			Inches over a 4-foot length	Total deviation (inches)	Inches over a 4-foot length	Total deviation (inches)
Up-Gradient	1	11/15/1997	3/8	4 7/32	3/4	8 7/16
	2	11/13/1997	1/8	1 13/32	1/8	1 13/32
	3	11/15/1997	1/4	2 13/16	1/4	2 13/16
	4	11/14-15/1997	3/8	4 7/32	1/4	2 13/16
	5	11/17/1997	1/8	1 13/32	1/8	1 13/32
	6	11/16-17/1997	1/2	5 5/8	1/4	2 13/16
	7	11/17-20/1997	1/8	1 13/32	0	0
	8	11/17/1997	1/8	1 13/32	0	0
	9	11/20/1997	1/4	2 13/16	1/4	2 13/16
	10	11/20/1997	0	0	1/8	1 13/32
	11	11/20-21/1997	1/4	2 13/16	0	0
	12	11/20/1997	1/4	2 13/16	1/4	2 13/16
	13	11/21-22/1997	1/2	5 5/8	1/4	2 13/16
	14	11/21/1997	1/4	2 13/16	1/8	1 13/32
	15	11/22/1997	3/8	4 7/32	1/4	2 13/16
	16	11/21/1997	3/8	4 7/32	1/4	2 13/16
	17	11/22-25/1997	1/8	1 13/32	1/4	2 13/16
	18	11/22/1997	3/8	4 7/32	3/8	4 7/32
First Down-Gradient	19	11/25/1997	3/8	4 7/32	1/8	1 13/32
	20	11/26/1997	1/4	2 13/16	1/4	2 13/16
	21	11/25/1997	1/4	2 13/16	0	0
Second Down-Gradient	22	11/26/1997	1/4	2 13/16	3/8	4 7/32
	23	11/28/1997	1/4	2 13/16	1/4	2 13/16
	24	11/26/1997	1/4	2 13/16	3/8	4 7/32

TABLE 6-5
JET ASSISTED GROUTING INSTALLATION COSTS

SUBCONTRACTOR CHARGES (FOREMOST & PEERLESS)	
Mobilization:	$ 40,000.00
Test Area (including estimated cost of iron used in testing)	$ 30,899.01
Demobilization:	$ 20,000.00
Installation:	$ 80,000.00
Iron (Excluding iron used for testing):	$ 73,563.12
SUBTOTAL SUBCONTRACTORS:	**$244,462.13**

Incidental Costs(Based on 41 days elapsed time on site, plus 2 weeks delay in mobilization)

	ITEM	UNITS	$/UNITS	NO. UNITS	TOTAL $
Temporary Facilities					
1	Port-O-let	Month	$73.67	1.83	$135.06
2	Barricades	Month	$386.37	1.83	$708.35
	Subtotal				$843.41
Construction Oversight					
3	Phone	Month	$336.37	1.37	$459.70
4	Noise Monitor	Month	$100.00	1.83	$183.33
5	Ford F150	Day	$46.08	41.00	$1,889.28
6	Explosimeter	Week	$79.60	5.86	$466.23
7	Field Oversight	Day	$593.00	38	$22,534.00
8	Daily Expenses	Day	$28.00	38	$1,064.00
9	Engineering Inspection	Each	$2,500.00	2	$5,000.00
10	Rust Personnel Unload Iron	Total	$1,500.00	1	$1,500.00
11	Review and approve contractor design changes, field oversight during delays caused by changes and safety training for contractor personnel.	Total	$6,000.00	1	$6,000.00
12	Miscellaneous field supplies	Ea.	$1,500.00	1	$1,500.00
	Subtotal				$40,596.54
IDW Management, Disposal					
13	Roll off delivery, each	Ea.	$1,250.00	2	$2,500.00
14	Roll-off rental	Ea./day	$10.00	105	$1,050.00
15	Haul Non-haz load	Each	$1,250.00	2	$2,500.00
16	Dispose IDW solid	Ton	$35.00	24.08	$842.80

TABLE 6-5
JET ASSISTED GROUTING INSTALLATION COSTS (CONCLUDED)

	ITEM	UNITS	$/UNITS	NO. UNITS	TOTAL $
17	IDW analysis – solid	Each	$1,262.50	1	$1,262.50
18	IDW analysis – liquid	Each	$775.00	1	$775.00
19	Data Validation, IDW samples	Total	$646.00	2	$1,292.00
20	Baker Tank Rental	Total	$3,411.00	1	$3,411.00
21	Transfer drums into tank, drain tank, move soils, US Environmental	Hr	$35.00	51.5	$1,802.50
22	Rust sampling, oversight of IDW	Total	$2,500.00	1	$2,500.00
23	Kemron, collect IDW from trench	Total	$300.00	1	$300.00
	Subtotal				$18,235.80
Additional Restoration					
24	Additional Restoration Work, Clean-up after Foremost Left, Rust	Total	$1,500.00	1	$1,500.00
25	Additional saw cut, seeding, Kemron	Total	$900.00	1	$900.00
	Subtotal				$2,400.00
SUBTOTAL INCIDENTALS					$62,075.75
TOTAL INSTALLATION OF JAG WALL					**$306,537.88**

TABLE 6-6
GROUNDWATER PUMP AND TREAT COST ESTIMATE

Part 1: Installed Equipment Costs					
Item	Units	No. Units	Unit Cost	Cost	Source
Site Prep/Restoration					
Mobilization	LS	1	$1,100	$1,100	Cost on PeRT Wall project
Cut asphalt for wells & pipe trench	LS	1	$1,700	$1,700	Cost on PeRT Wall project
Trenching/Backfill	LS	1	$2,268	$2,268	Cost on PeRT Wall project
Slab on Grade, 6"	SF	1250	$4.28	$5,350	Echos, 97, 18 02 0322
Remove/Dispose asphalt	SY	67	17.75	$1,183	Cost on PeRT Wall project
Replace Asphalt	SY	67	14.09	$939	Cost on PeRT Wall project
Reseeding	LS	1	$150	$150	Cost on PeRT Wall project
Subtotal				**$12,691**	
Extraction Wells, Vaults, Influent Piping and Controls Installation					
Driller Mobilization	LS	1	$400	$400	Cost on PeRT Wall project
4" Stainless Steel well casing	LF	25	$54	$1,350	Echos, 97, 33 23 0122
4" Stainless Steel well screen	LF	15	$65	$975	Echos, 97, 33 23 0222
3/4 HP pumps, 230V, controls	Each	1	$5,715	$5,715	Echos, 97, 33 23 0602
Explosion proof electrical	Each	1	$420	$420	Echos, 97, 33 23 0811
Drill & Test wells	LF	40	$55	$2,200	Echos, 97, 33 23 1143
Control Panel, at treatment equipment	Each	1	$7,052	$7,052	Echos, 97, 33 23 1302
Well vaults, traffic load	Each	1	$3,319	$3,319	Echos, 97, 33 23 1302
Piping, 1" stainless steel + fittings	LF	200	$13.30	$2,660	Echos, 97, 33 26 0231
Subtotal				**$24,091**	
Treatments System, effluent piping and controls Installation					
Air Stripper, Purchase	Each	1	$7,500	$7,500	Delta Cooling Towers
Level Controls (NEMA 7)	Each	1	$1,080	$1,080	Delta Cooling Towers
Explosion proof fan motor	Each	1	$525	$525	Delta Cooling Towers
Control Panel	Each	1	$3,130	$3,130	Delta Cooling Towers
Shipping	Each	1	$1,000	$1,000	Delta Cooling Towers

TABLE 6-6
GROUNDWATER PUMP AND TREAT COST ESTIMATE (Continued)

Item	Units	No. Units	Unit Cost	Cost	Source
Air Stripper, Install	Each	1	$39,705	$39,705	Assume equip = 1/4 installed
Liquid GAC Deliver 2 cells	Each	2	$1,800	$3,600	Calgon
Liquid GAC rental fee	Each	2	$790	$1,580	Calgon
Liquid GAC testing fee	Each	1	$1,000	$1,000	Calgon
Vapor GAC deliver 2 cells	Each	2	$3585	$7,170	Calgon
Vapor GAC rental fee	Each	2	$275	$550	Calgon
Vapor GAC testing fee	Each	1	$1,000	$1,000	Calgon
Discharge piping to sewer	LF	75	$5.65	$424	Echos, 97, 19 02 0101
Precast manhole	Each	3	$612.95	$1,839	Echos, 97, 19 02 0201
550 Gal Steel Sump	Each	1	$1,110	$1,110	Echos, 97, 19 04 0602
Backflow Preventor	Each	1	$1,000	$1,000	Previous Project Costs
Subtotal				**$72,213**	
Monitoring Well Installation					
Total Installation per well	**Each**	**4**	**$1,419**	**$5,676**	Cost on PeRT Wall project
Construction Oversight					
Construction oversight - labor	Day	60	$593	$35,580	Cost on PeRT Wall project
Construction oversight - expenses	Month	3	$2,556	$7,668	Cost on PeRT Wall project
Subtotal				**$43,248**	
Miscellaneous Other Direct Costs					
IDW sampling	Each	3	$1,262	$3,786	Cost on PeRT Wall project
IDW storage	Month	1	$300	$300	Cost on PeRT Wall project
IDW transport	Each	1	$1,250	$1,250	Cost on PeRT Wall project
IDW disposal	Ton	10	$55	$550	Cost on PeRT Wall project
Port-O-Lets	Month	3	$74	$222	Cost on PeRT Wall project
Barricades	Month	3	$386	$1,158	Cost on PeRT Wall project
Subtotal				**$7,266**	
TOTAL INSTALLED COST				**$165,185**	
Part 2: Operations and Maintenance - 10 Months					
Packing Recondition	EA	0	$2,094	$0	Echos, 97, 33 13 0701
Blower and Motor maintenance	EA	1	$356	$356	Echos, 97, 33 41 0201

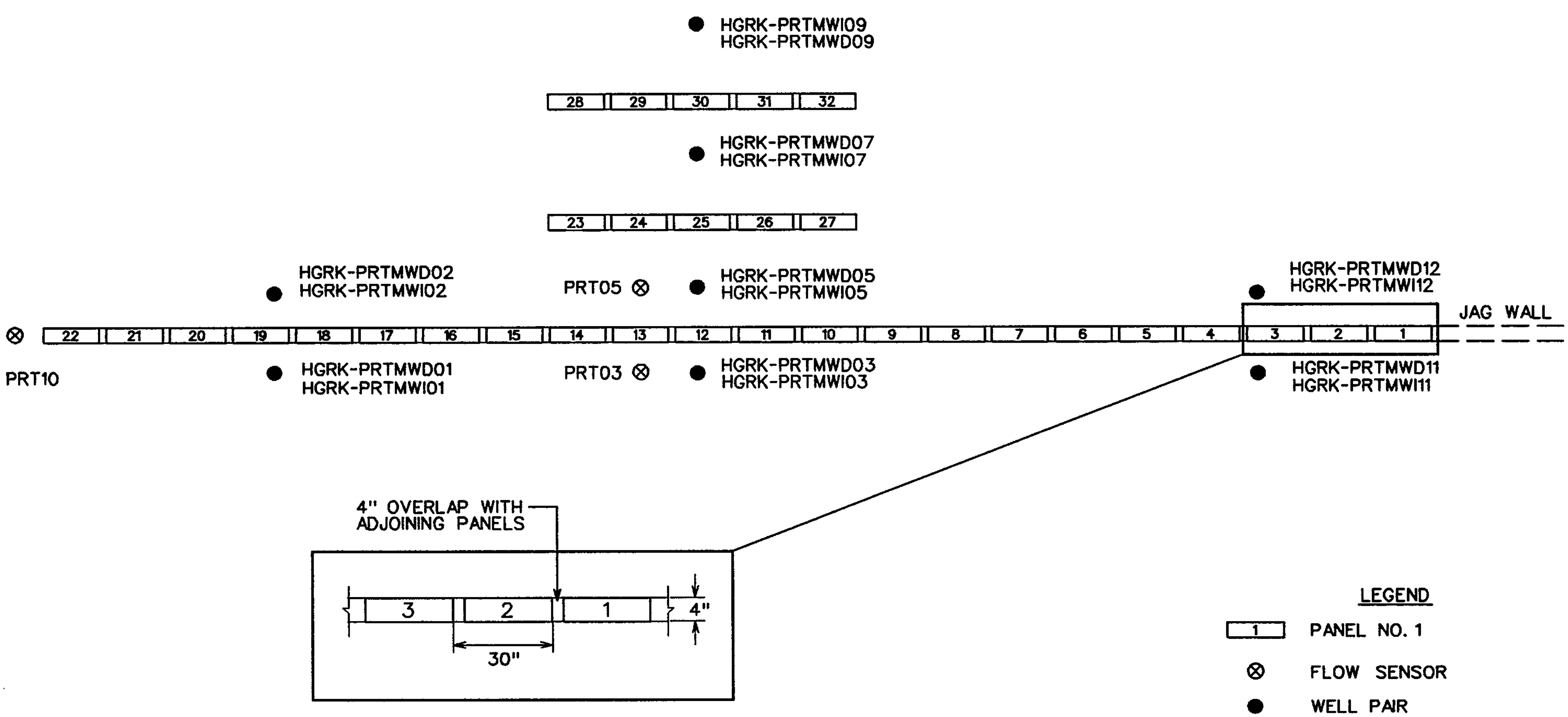
TABLE 6-6
GROUNDWATER PUMP AND TREAT COST ESTIMATE (Continued)

Item	Units	No. Units	Unit Cost	Cost	Source
Pump Maintain	EA	1	$356	$356	Echos, 97, 33 41 0101
Electrical	kWh	9,274	$0.03	$306	Typical
Sewage Surcharge	Gal	6,048,000	$0.01	$60,480	Typical
Carbon Change out - liquid	EA	15	$1,800	$27,000	Calgon
Liquid phase rental	EA	15	$790	$11,850	Calgon
Carbon Change out - vapor	EA	10	$3,585	$35,850	Calgon
Vapor phase rental	EA	10	$275	$2,750	Calgon
Subtotal O&M				**$139,000**	
Monitoring - Quarterly Sampling, monthly effluent and carbon breakthrough					
Labor	Each	4	$10,695	$42,780	Cost on PeRT Wall project
Laboratory Analysis, 5 samples	Event	4	$550	$2,200	Cost on PeRT Wall project
Monitoring – Monthly Effluent and Carbon Breakthrough					
Labor	Each	6	$400	$2,400	Estimated cost travel, sampling
Laboratory Analysis, 10 samples	Each	10	$110	$1,100	Cost on PeRT Wall project
Monitoring – Weekly Carbon vapor and liquid phase breakthrough					
Labor	Each	33	$400	$13,333	Estimated cost travel, sampling
Laboratory Analysis, 10 samples	Each	33	$110	$4,767	Cost on PeRT Wall project
Subtotal Monitoring				**$66,580**	

TABLE 6-7
COST COMPARISON, PeRT WALL vs. PUMP AND TREAT

Item	Pert Wall Cost – Both Pilot Test Walls (Actual)	Groundwater Pump And Treat – Basis Equal Volume Treated (Estimated)	Difference
INSTALLATION			
Site Prep and Restoration	$57,200	$12,700	
Monitoring Well Installation	$45,400	$5,700	
Flow Sensors	$36,300	$0	
Install System	$534,200	$96,300	
Construction Oversight	$58,300	$43,200	
IDW Handling/Disposal	$18,200	$5,900	
Other ODCs	$1,200	$1,400	
TOTAL INSTALLATION	**$750,800**	**$165,200**	**$585,600**
OPERATION AND MAINTENANCE (10 MONTHS)			
Sampling and Analysis*	$47,600	$66,600	
Equipment O&M	$0	$700	
Utilities (electric, sewer)	$0	$60,800	
Carbon Use	$0	$77,500	
TOTAL O&M (10 Months)	**$47,600**	**$205,600**	**$-158,000**
TOTAL INSTALLATION & O&M FOR 10 MONTHS	**$798,400**	**$370,800**	
ESTIMATED TIME REQUIRED FOR O&M SAVINGS TO OFFSET ADDITIONAL CAPITAL COST	**4 YEARS**	**N/A**	

*NOTE: The actual cost of monitoring during the pilot study was approximately $200,000. However, this was much more than would be required during a remedial action. Therefore, the cost of $47,600 was used to represent an equal monitoring level with the "pump and treat" technology (see Table 6-6).



NOT TO SCALE

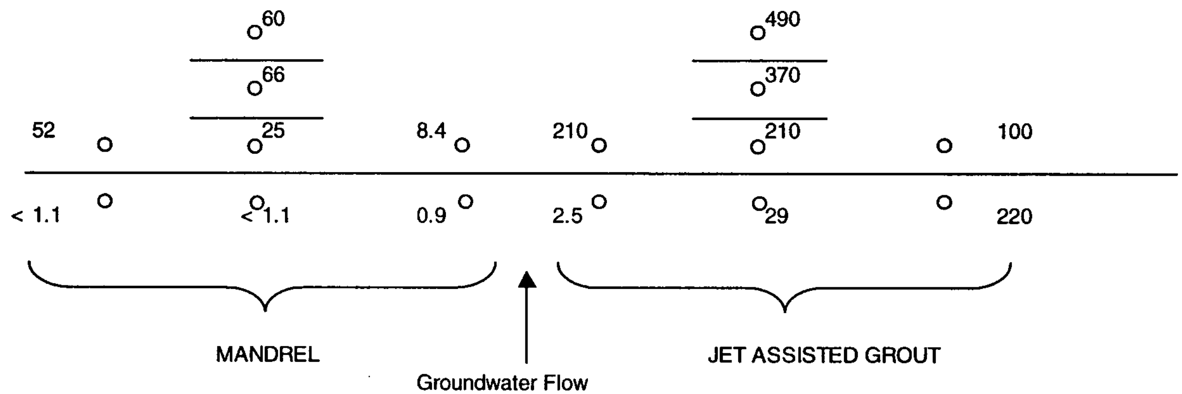
RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 6–1
LAYOUT OF MANDREL WALL PANELS

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK12.DGN

Vinyl Chloride, February 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	1.1	52	-4627% *		2.5	210	-8300%
	1.1	25	-2173% *		29	210	-624%
	25	66	-164%		210	370	-76%
	66	60	9%		370	490	-32%
	0.9	8.4	-833%		220	100	55%
Average			**-1558%**				**-1796%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

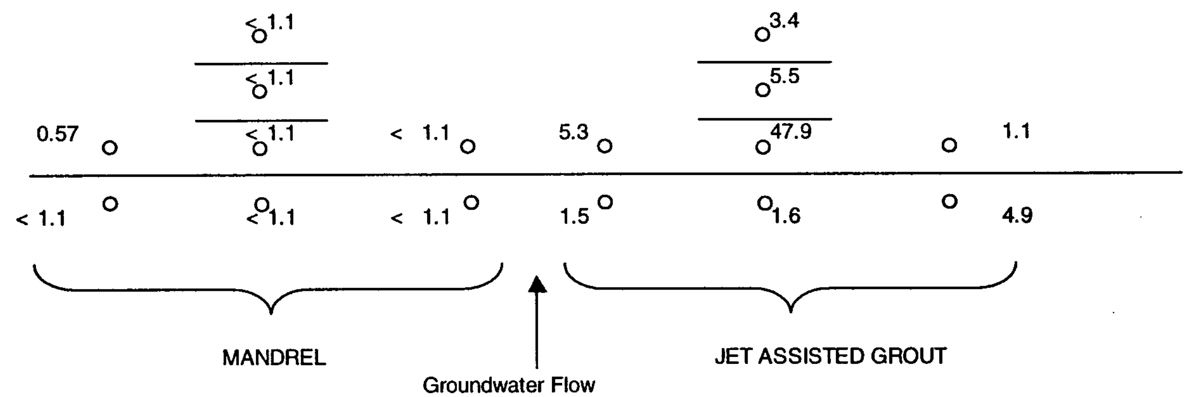
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

Rust Environment & Infrastructure

FIGURE 6-2
VOC Concentration in wells screened
15 to 20 feet bls
Sheet 1 of 8: Vinyl chloride, February 1998
Cape Canaveral Air Station, Florida

Vinyl Chloride, August 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	1.1	0.57	0% *		1.5	5.3	-253%
	1.1	1.1	0% *		1.6	47.9	-2894%
	1.1	1.1	0% *		47.9	5.5	89%
	1.1	1.1	0% *		5.5	3.4	38%
	1.1	1.1	0% *		4.9	1.1	78%
Average			**0%**				**-589%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

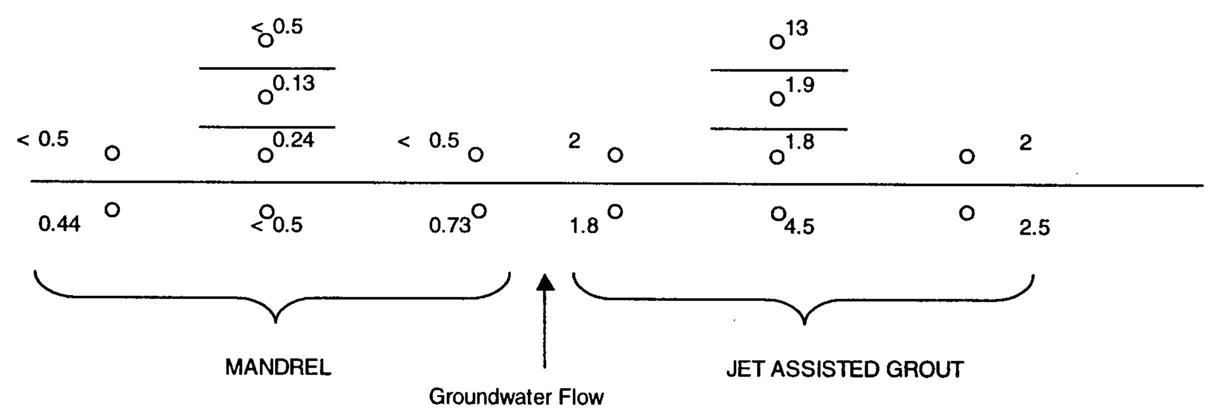
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

Rust Environment & Infrastructure

FIGURE 6-2
VOC Concentration in wells screened
15 to 20 feet bls
Sheet 2 of 8: Vinyl chloride, August 1998
Cape Canaveral Air Station, Florida

trans-1,2 Dichloroethene, February 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	0.44	0.5	0% *		1.8	2	-11%
	0.5	0.24	0% *		4.5	1.8	60%
	0.24	0.13	46%		1.8	1.9	-6%
	0.13	0.5	0% *		1.9	13	-584%
	0.73	0.5	32%		2.5	2	20%
Average			**15%**				**-104%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

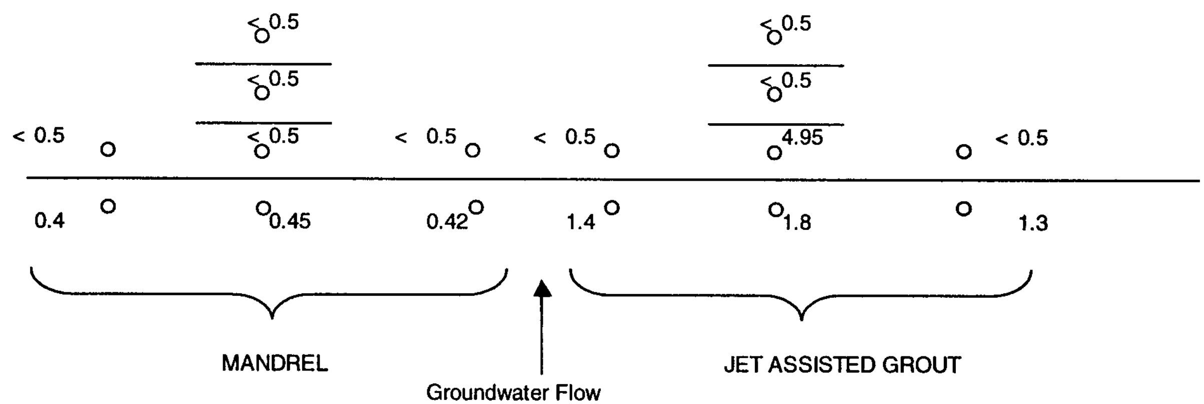
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-2
VOC Concentration in wells screened 15 to 20 feet bls
Sheet 3 of 8: trans-1,2 DCE, February 1998
Cape Canaveral Air Station, Florida

trans-1,2 Dichloroethene, August 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	0.4	0.5	0% *		1.4	0.5	64% *
	0.45	0.5	0% *		1.8	4.95	-175%
	0.5	0.5	0% *		4.95	0.5	90% *
	0.5	0.5	0% *		0.5	0.5	0% *
	0.42	0.5	0% *		1.3	0.5	62% *
Average			**0%**				**8%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

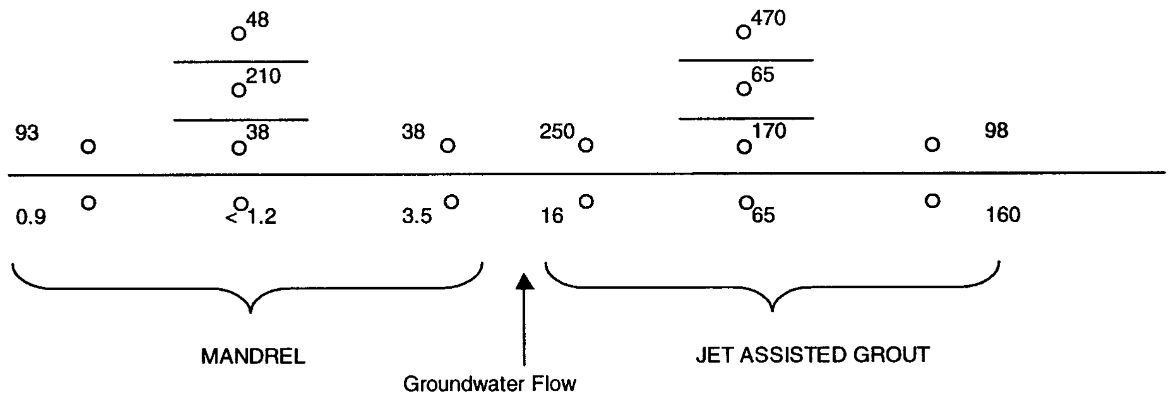
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-2
VOC Concentration in wells screened 15 to 20 feet bls
Sheet 4 of 8: trans-1,2 DCE, August 1998
Cape Canaveral Air Station, Florida

cis-1,2 Dichloroethene, February 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	0.9	93	-10233%		16	250	-1463%
	1.2	38	-3067% *		65	170	-162%
	38	210	-453%		170	65	62%
	210	48	77%		65	470	-623%
	3.5	38	-986%		160	98	39%
Average			**-2932%**				**-429%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

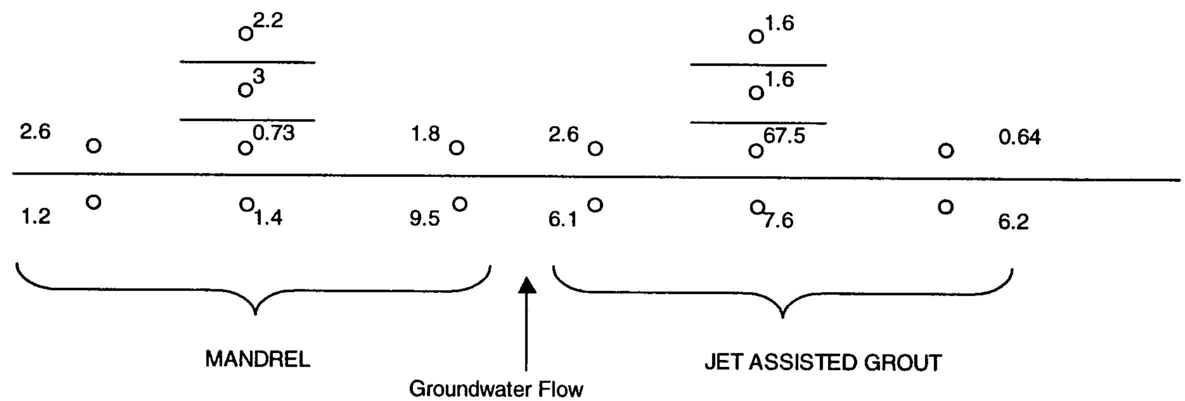
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

Rust Environment & Infrastructure

FIGURE 6-2
VOC Concentration in wells screened 15 to 20 feet bls
Sheet 5 of 8: cis-1,2 DCE, February 1998
Cape Canaveral Air Station, Florida

cis-1,2 Dichloroethene, August 1998



Performance Across 4" thickness

Mandrel	Up	Down	% Reduction or increase	Jet Assisted Grout	Up	Down	% Reduction or increase
	1.2	2.6	-117%		6.1	2.6	57%
	1.4	0.73	48%		7.6	67.5	-788%
	0.73	3	-311%		67.5	1.6	98%
	3	2.2	27%		1.6	1.6	0%
	9.5	1.8	81%		6.2	0.64	90%
Average			**-54%**				**-109%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

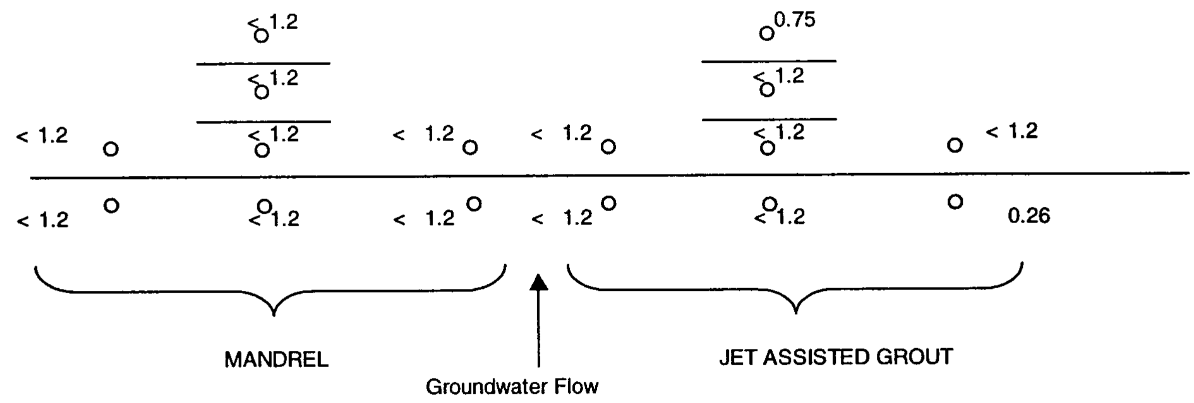
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

Rust Environment & Infrastructure

FIGURE 6-2
VOC Concentration in wells screened 15 to 20 feet bls
Sheet 6 of 8: cis-1,2 DCE, August 1998
Cape Canaveral Air Station, Florida

1,1-Dichloroethene, February 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	1.2	1.2	0% *		1.2	1.2	0% *
	1.2	1.2	0% *		1.2	1.2	0% *
	1.2	1.2	0% *		1.2	1.2	0% *
	1.2	1.2	0% *		1.2	0.75	0% *
	1.2	1.2	0% *		0.26	1.2	0% *
Average			**0%**				**0%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

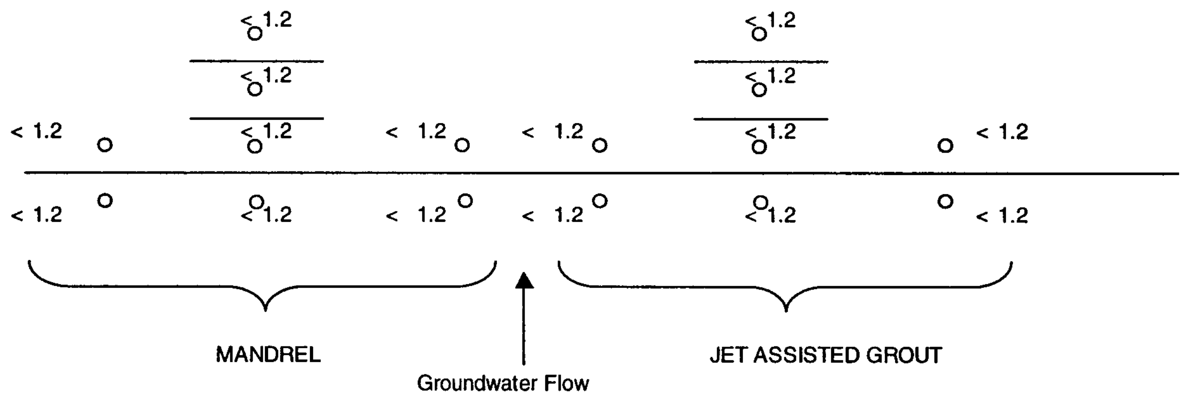
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

RUST
Rust Environment & Infrastructure

FIGURE 6-2
VOC Concentration in wells screened
15 to 20 feet bls
Sheet 7 of 8: 1,1-DCE, February 1998
Cape Canaveral Air Station, Florida

1,1-Dichloroethene, August 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	1.2	1.2	0% *		1.2	1.2	0% *
	1.2	1.2	0% *		1.2	1.2	0% *
	1.2	1.2	0% *		1.2	1.2	0% *
	1.2	1.2	0% *		1.2	1.2	0% *
	1.2	1.2	0% *		1.2	1.2	0% *
Average			**0%**				**0%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

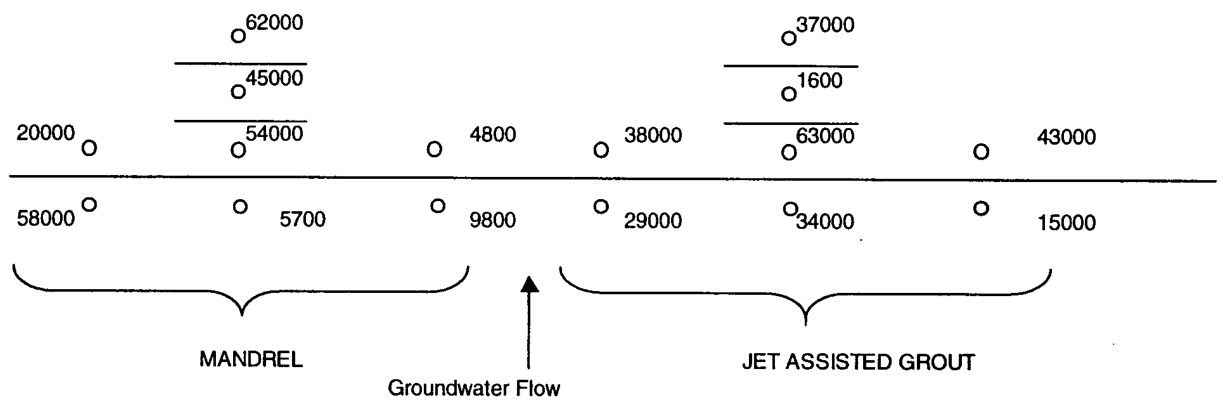
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-2
VOC Concentration in wells screened 15 to 20 feet bls
Sheet 8 of 8: 1,1-DCE, August 1998
Cape Canaveral Air Station, Florida

Vinyl Chloride, February 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	58000	20000	66%		29000	38000	-31%
	5700	54000	-847%		34000	63000	-85%
	54000	45000	17%		63000	1600	97%
	45000	62000	-38%		1600	37000	-2213%
	9800	4800	51%		15000	43000	-187%
Average			**-150%**				**-484%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

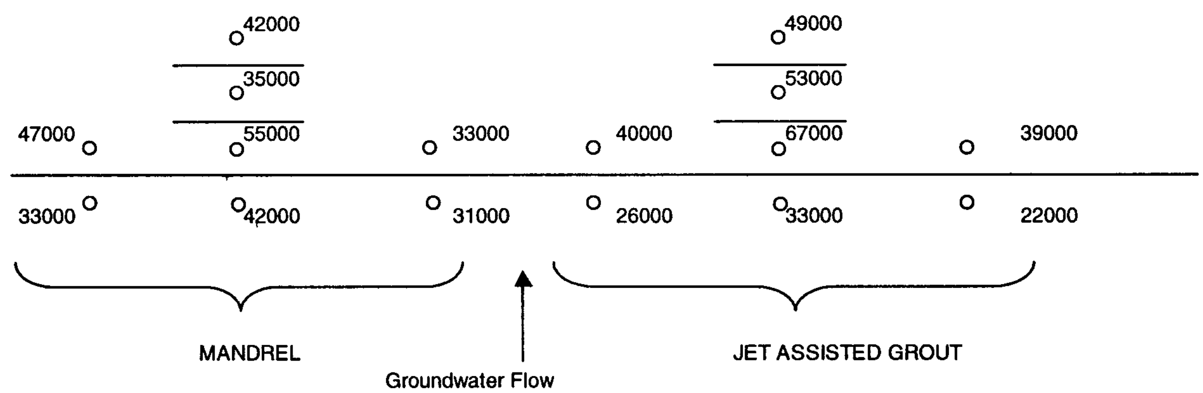
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 1 of 16: Vinyl Chloride, February 1998
Cape Canaveral Air Station, Florida

Vinyl Chloride, May 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	33000	47000	-42%		26000	40000	-54%
	42000	55000	-31%		33000	67000	-103%
	55000	35000	36%		67000	53000	21%
	35000	42000	-20%		53000	49000	8%
	31000	33000	-6%		22000	39000	-77%
Average			**-13%**				**-41%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

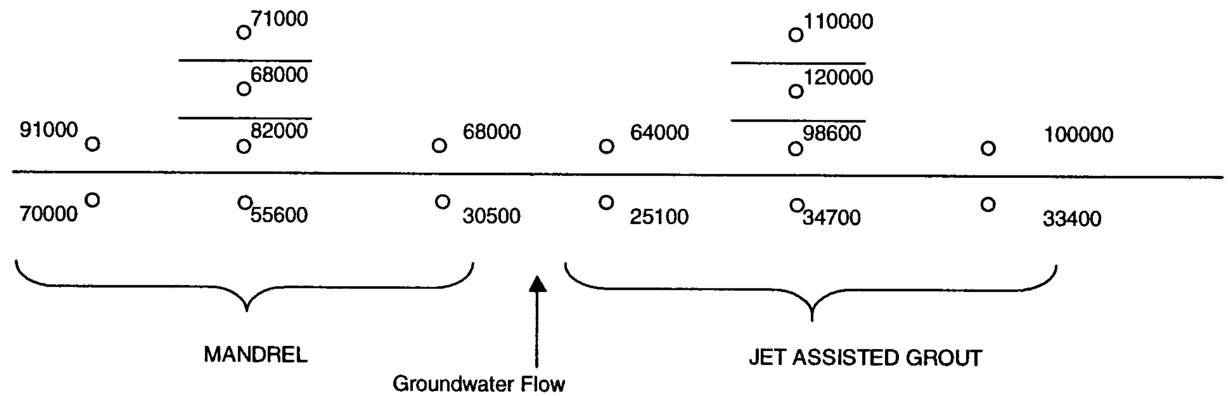
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 2 of 16: Vinyl Chloride, May 1998
Cape Canaveral Air Station, Florida

Vinyl Chloride, August 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	70000	91000	-30%		25100	64000	-155%
	55600	82000	-47%		34700	98600	-184%
	82000	68000	17%		98600	120000	-22%
	68000	71000	-4%		120000	110000	8%
	30500	68000	-123%		33400	100000	-199%
Average			**-38%**				**-110%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

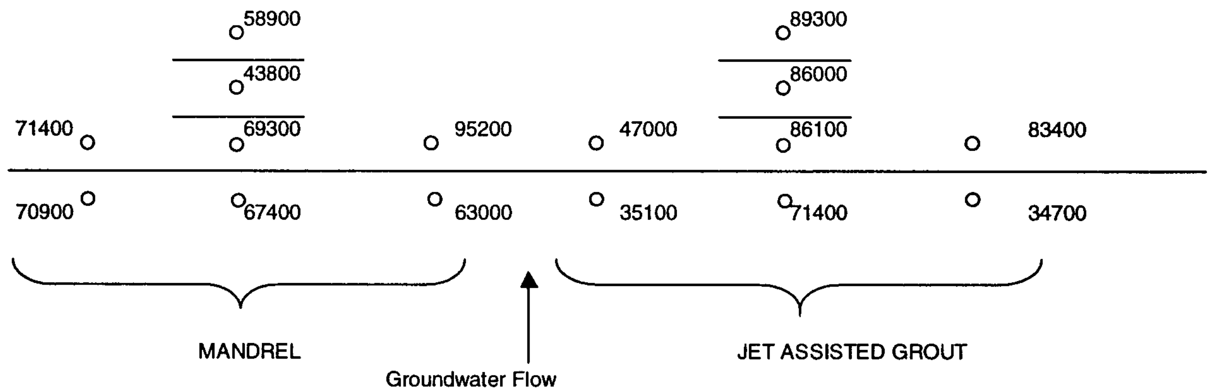
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 3 of 16: Vinyl Chloride, August 1998
Cape Canaveral Air Station, Florida

Vinyl Chloride, November 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	70900	71400	-1%		35100	47000	-34%
	67400	69300	-3%		71400	86100	-21%
	69300	43800	37%		86100	86000	0%
	43800	58900	-34%		86000	89300	-4%
	63000	95200	-51%		34700	83400	-140%
Average			**-10%**				**-40%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

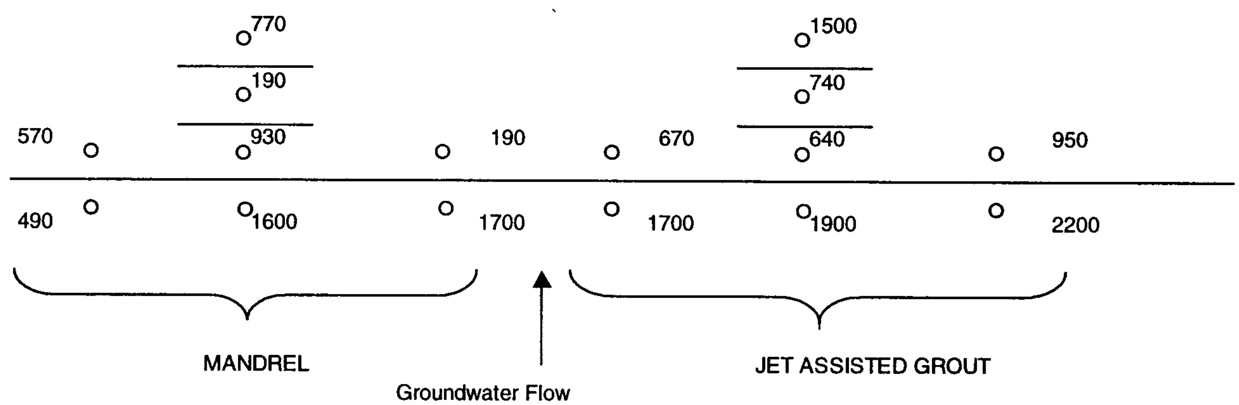
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 4 of 16: Vinyl Chloride, November 1998
Cape Canaveral Air Station, Florida

trans-1,2 Dichloroethene, February 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	490	570	-16%		1700	670	61%
	1600	930	42%		1900	640	66%
	930	190	80%		640	740	-16%
	190	770	-305%		740	1500	-103%
	1700	190	89%		2200	950	57%
Average			**-22%**				**13%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

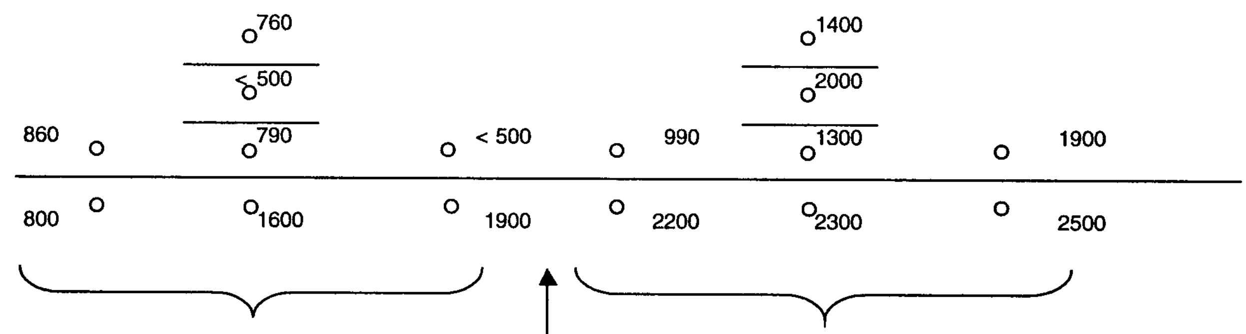
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 5 of 16: trans-1,2 DCE, February 1998
Cape Canaveral Air Station, Florida

trans-1,2 Dichloroethene, May 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	800	860	-8%		2200	990	55%
	1600	790	51%		2300	1300	43%
	790	500	37% *		1300	2000	-54%
	500	760	-52% *		2000	1400	30%
	1900	500	74% *		2500	1900	24%
Average			**20%**				**20%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

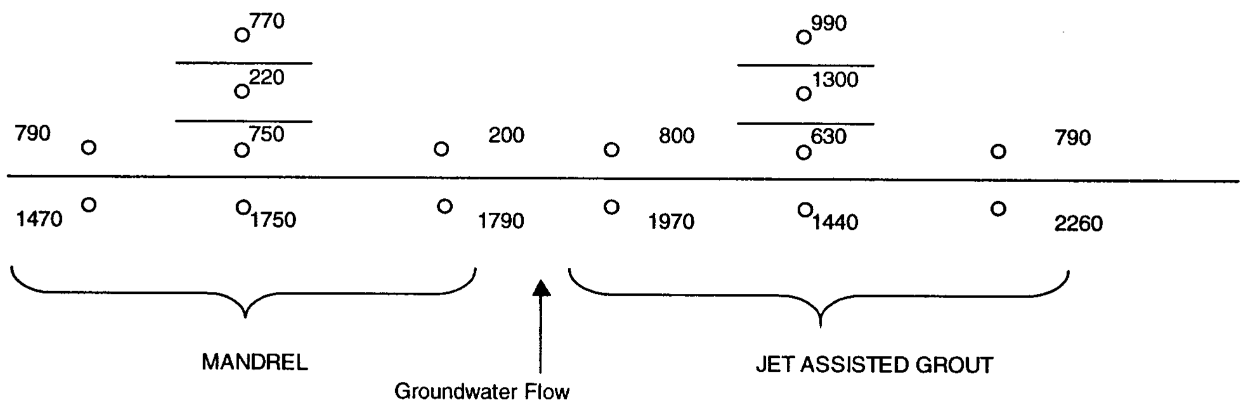
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 6 of 16: trans-1,2 DCE, May 1998
Cape Canaveral Air Station, Florida

trans-1,2 Dichloroethene, August 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	1470	790	46%		1970	800	59%
	1750	750	57%		1440	630	56%
	750	220	71%		630	1300	-106%
	220	770	-250%		1300	990	24%
	1790	200	89%		2260	790	65%
Average			**3%**				**20%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

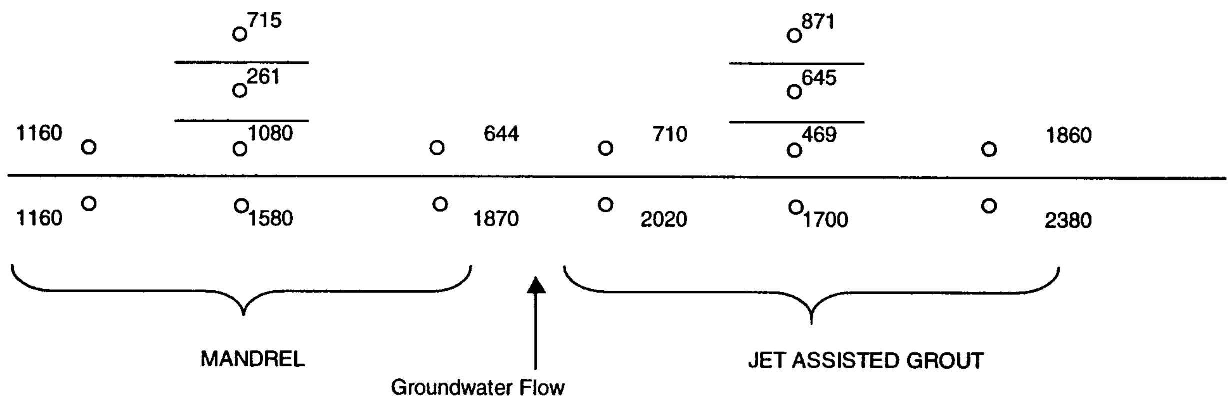
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 7 of 16: trans-1,2 DCE, August 1998
Cape Canaveral Air Station, Florida

trans-1,2 Dichloroethene, November 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	1160	1160	0%		2020	710	65%
	1580	1080	32%		1700	469	72%
	1080	261	76%		469	645	-38%
	261	715	-174%		645	871	-35%
	1870	644	66%		2380	1860	22%
Average			**0%**				**17%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

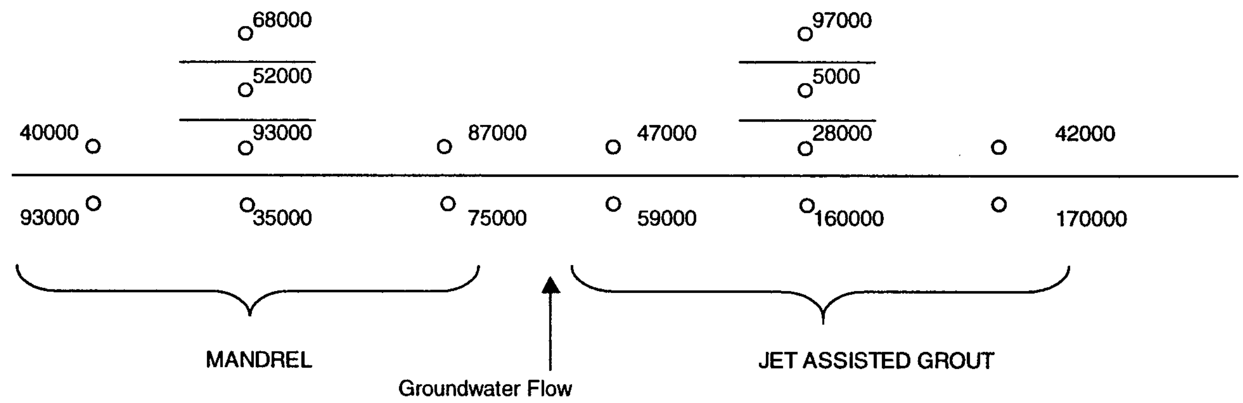
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 8 of 16: trans-1,2 DCE, November 1998
Cape Canaveral Air Station, Florida

cis-1,2 Dichloroethene, February 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	93000	40000	57%		59000	47000	20%
	35000	93000	-166%		160000	28000	83%
	93000	52000	44%		28000	5000	82%
	52000	68000	-31%		5000	97000	-1840%
	75000	87000	-16%		170000	42000	75%
Average			**-22%**				**-316%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

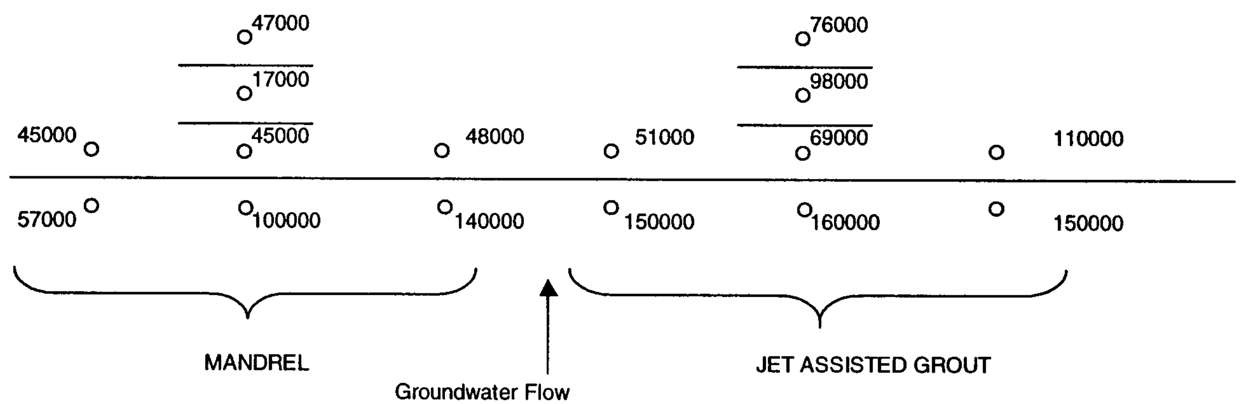
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 9 of 16: cis-1,2 DCE, February 1998
Cape Canaveral Air Station, Florida

cis-1,2 Dichloroethene, May 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	57000	45000	21%		150000	51000	66%
	100000	45000	55%		160000	69000	57%
	45000	17000	62%		69000	98000	-42%
	17000	47000	-176%		98000	76000	22%
	140000	48000	66%		150000	110000	27%
Average			**6%**				**26%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

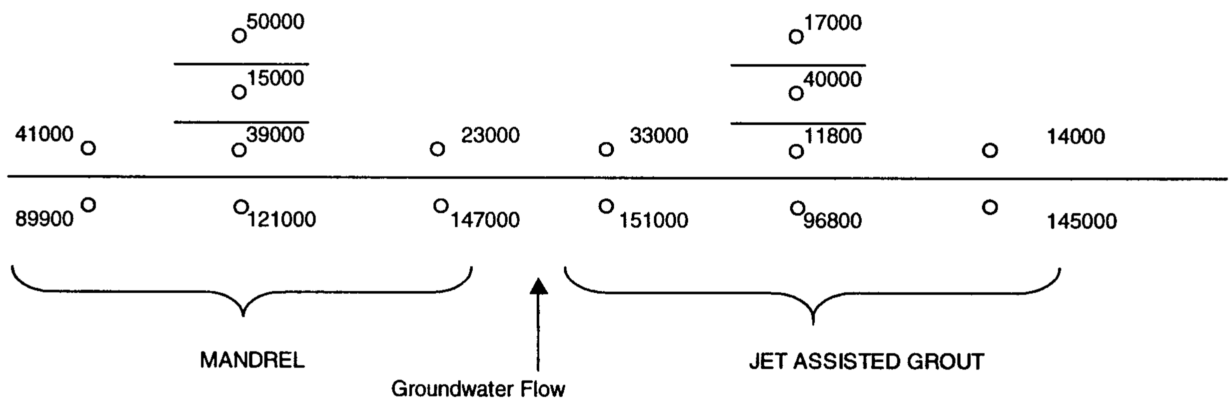
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 10 of 16: cis-1,2 DCE, May 1998
Cape Canaveral Air Station, Florida

cis-1,2 Dichloroethene, August 1998



Performance Across 4" thickness

Mandrel	Up	Down	% Reduction or increase	Jet Assisted Grout	Up	Down	% Reduction or increase
	89900	41000	54%		151000	33000	78%
	121000	39000	68%		96800	11800	88%
	39000	15000	62%		11800	40000	-239%
	15000	50000	-233%		40000	17000	58%
	147000	23000	84%		145000	14000	90%
Average			**7%**				**15%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

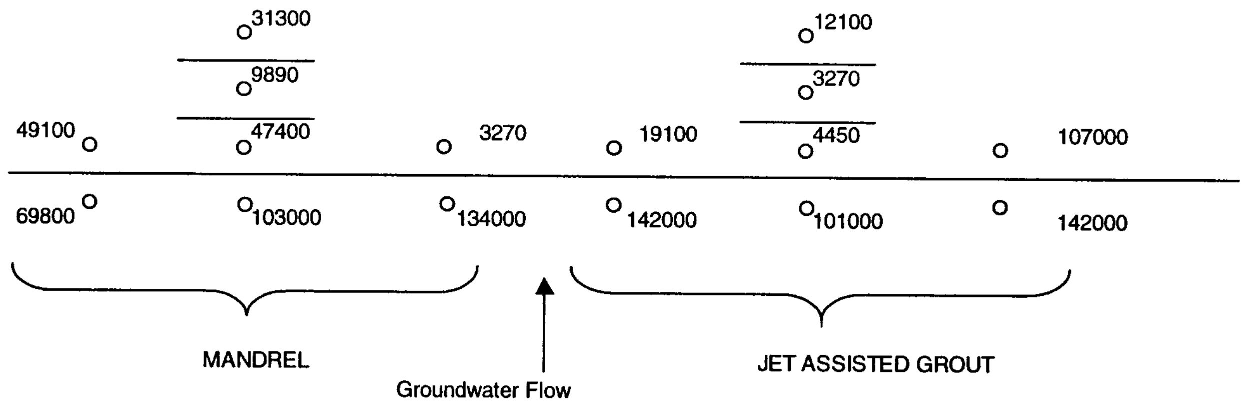
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 11 of 16: cis-1,2 DCE, August 1998
Cape Canaveral Air Station, Florida

cis-1,2 Dichloroethene, November 1998



Performance Across 4" thickness

Mandrel	Up	Down	% Reduction or increase	Jet Assisted Grout	Up	Down	% Reduction or increase
	69800	49100	30%		142000	19100	87%
	103000	47400	54%		101000	4450	96%
	47400	9890	79%		4450	3270	27%
	9890	31300	-216%		3270	12100	-270%
	134000	3270	98%		137000	107000	22%
Average			**9%**				**-8%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

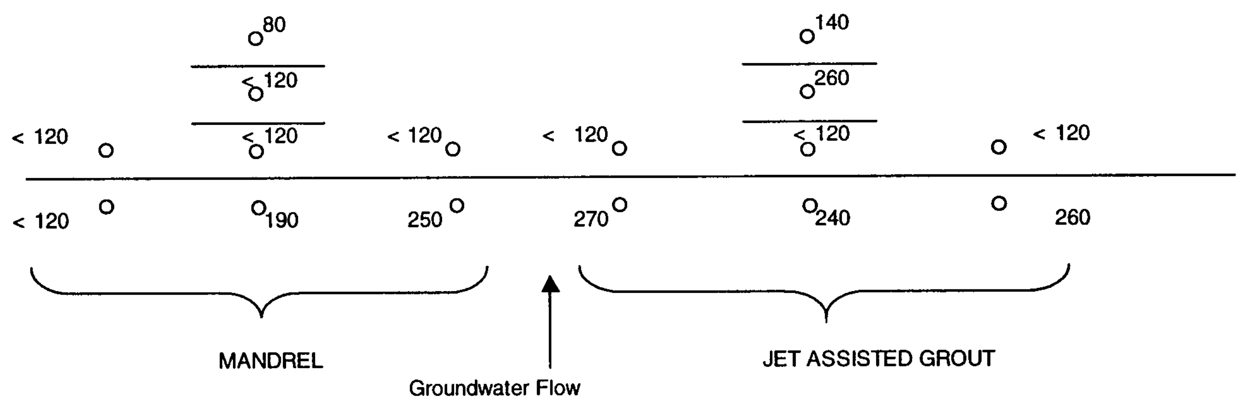
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 12 of 16: cis-1,2 DCE, November 1998
Cape Canaveral Air Station, Florida

1,1-Dichloroethene, February 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	120	120	0% *
	190	120	37% *
	120	120	0% *
	120	80	0% *
	250	120	52% *
Average			**18%**

Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	270	120	56% *
	240	120	50% *
	120	260	-117% *
	260	140	46% *
	260	120	54% *
			18%

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

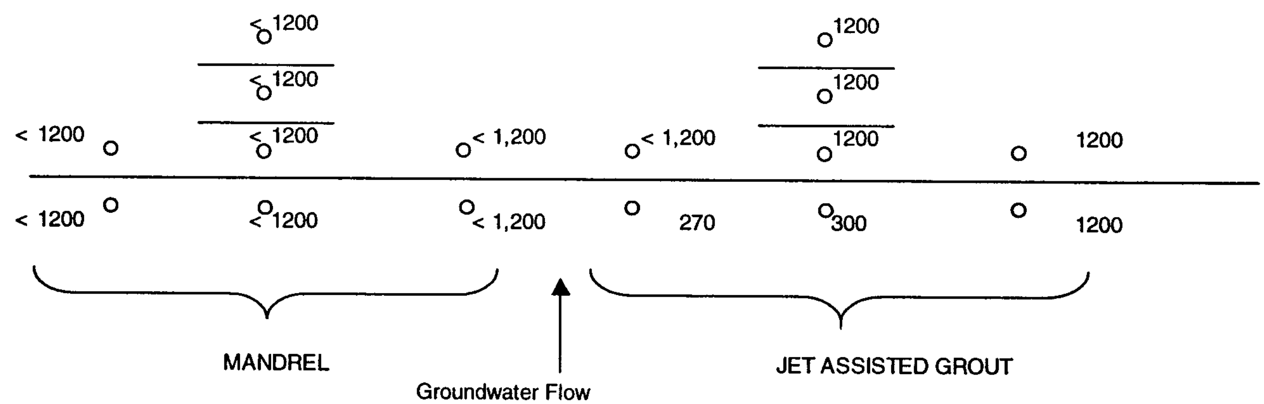
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

Note: Concentrations in ug/l

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 13 of 16: 1,1-DCE, February 1998
Cape Canaveral Air Station, Florida

1,1-Dichloroethene, May 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	1200	1200	0% *		270	1200	0% *
	1200	1200	0% *		300	1200	0% *
	1200	1200	0% *		1200	1200	0% *
	1200	1200	0% *		1200	1200	0% *
	1200	1200	0% *		1200	1200	0% *
Average			**0%**				**0%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

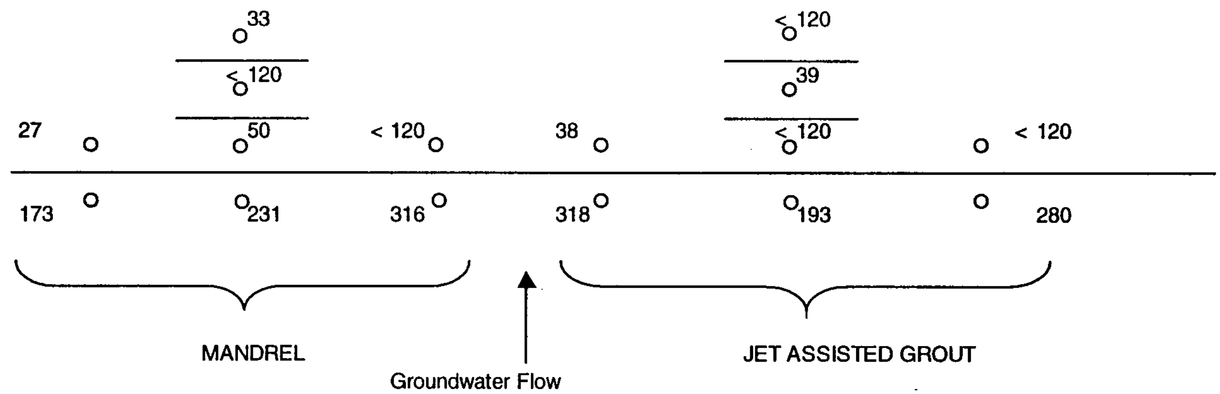
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 14 of 16: 1,1-DCE, May 1998
Cape Canaveral Air Station, Florida

1,1-Dichloroethene, August 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	173	27	84%		318	38	88%
	231	50	78%		193	120	38% *
	50	120	0% *		120	39	0% *
	120	33	0% *		39	120	0% *
	316	120	62%		280	120	57% *
Average			**45%**				**37%**

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

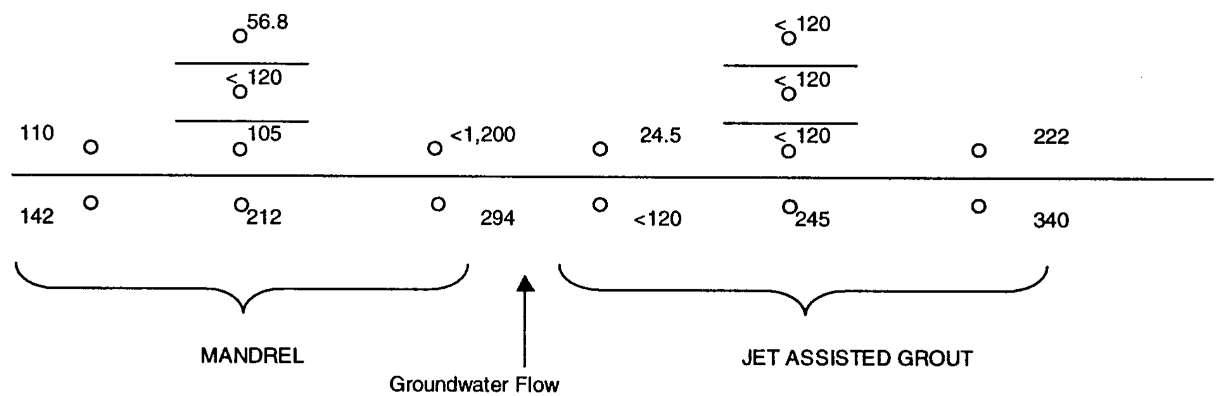
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 15 of 16: 1,1-DCE, August 1998
Cape Canaveral Air Station, Florida

1,1-Dichloroethene, November 1998



Performance Across 4" thickness

Mandrel	Up-Gradient Well	Down-Gradient Well	% Reduction or increase	Jet Assisted Grout	Up-Gradient Well	Down-Gradient Well	% Reduction or increase
	142	110	23%		120	24.5	0% *
	212	105	50%		245	120	51% *
	105	120	0% *		120	120	0% *
	120	56.8	0% *		120	120	0% *
	294	1200	0% *		340	222	35%
Average			15%				17%

* For concentrations reported as a less than detection level, the detection value is used to calculate % reduction, unless it is being compared with a number that has been reported as an estimated value that is less than the detection level. For example, a

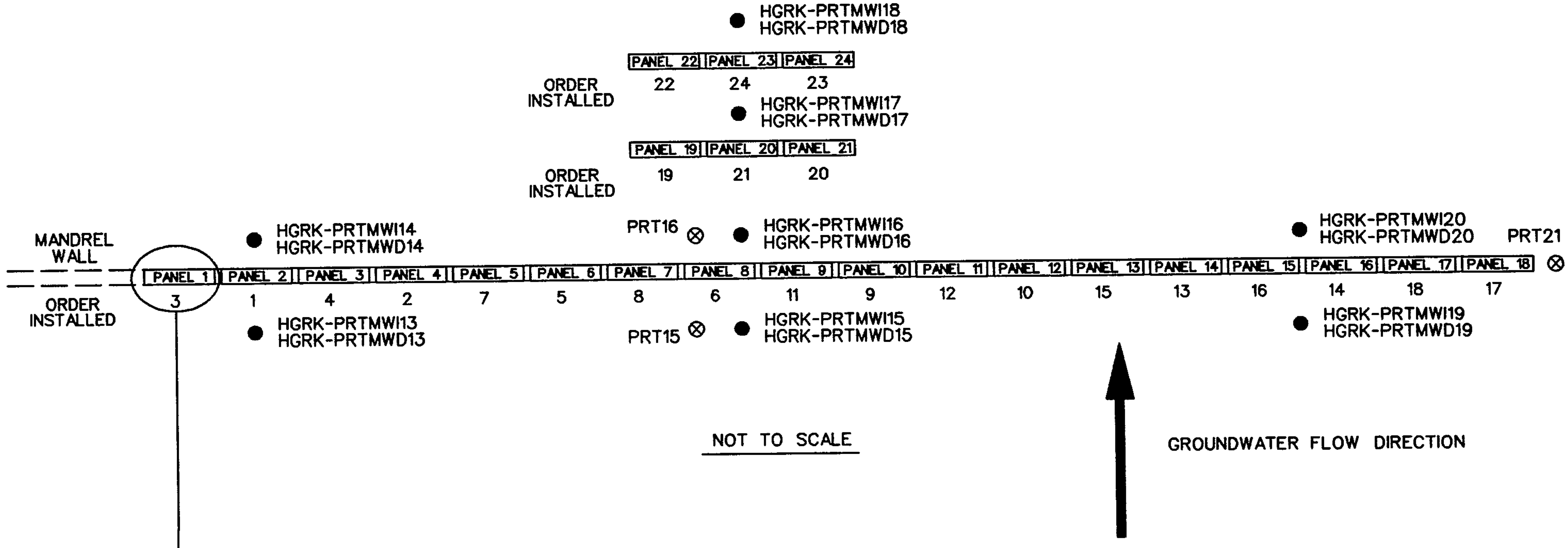
Note: A negative number in the "% Reduction or Increase" column indicates an increase in concentration from up-gradient to down-gradient wells. A positive number indicates a decrease in concentration from up-gradient to down-gradient wells.

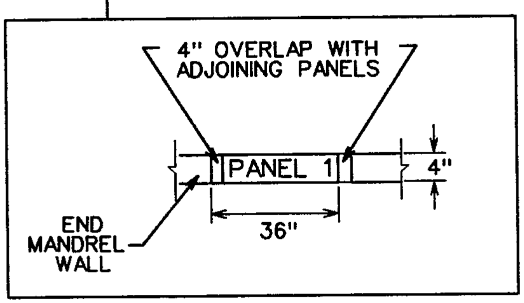
Note: Concentrations in ug/l

RUST

Rust Environment & Infrastructure

FIGURE 6-3
VOC Concentration in wells screened
35 to 40 feet bls
Sheet 16 of 16: 1,1-DCE, November 1998
Cape Canaveral Air Station, Florida





ORDER OF INSTALLATION	PANEL NO.
1	2
2	4
3	1
4	3
5	6
6	8
7	5
8	7
9	10
10	12
11	9
12	11

ORDER OF INSTALLATION	PANEL NO.
13	14
14	16
15	13
16	15
17	18
18	17
19	19
20	21
21	20
22	22
23	24
24	23

LEGEND

PANEL 1 — PANEL NO. 1

⊗ FLOW SENSOR

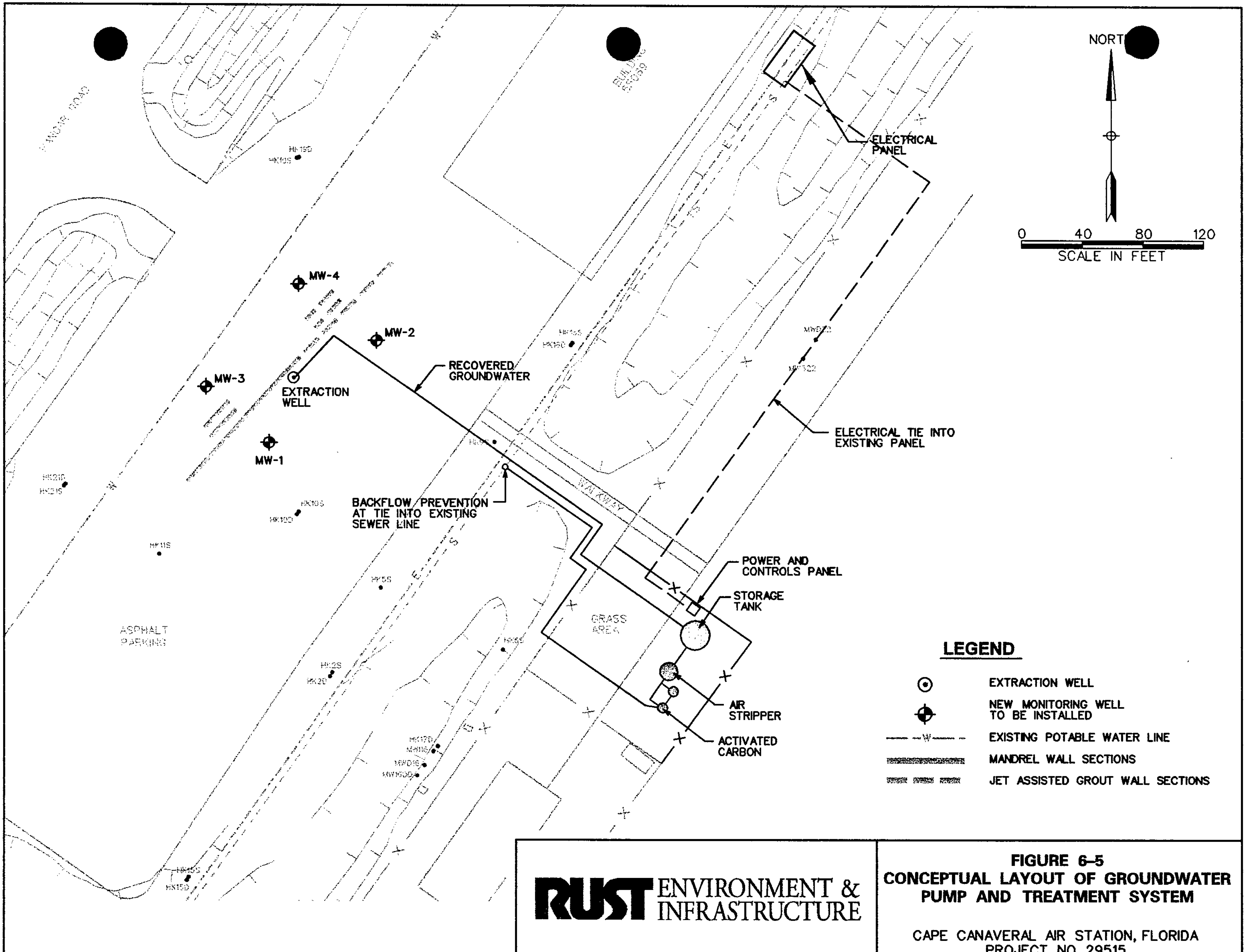
● WELL PAIR

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 6-4
LAYOUT OF JET ASSISTED GROUTING WALL PANELS

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

N:\39748\9748HK14.DGN



RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 6–5
CONCEPTUAL LAYOUT OF GROUNDWATER PUMP AND TREATMENT SYSTEM

CAPE CANAVERAL AIR STATION, FLORIDA
PROJECT NO. 29515

7.0 CONCLUSIONS

7.1 VOC DEGRADATION

The monitoring results collected during the first year of operation were insufficient to determine the effectiveness of the PeRT walls on groundwater restoration. Two of the reasons for inconclusive results include the slow rate of groundwater flow and the high variability of the influent chlorinated VOC concentrations. During installation of the monitoring wells, it was noted that the soils at 35 to 40 feet bls in this area are silty to clayey sands. High OVA readings (between 100 and 450 ppm) were noted on soil samples from these depth intervals. It is therefore likely that the chlorinated solvents at this depth are adsorbed onto the soils or exist as residual saturation. As water flows through a wall segment and is treated, it could be flushing additional chlorinated VOCs which may be desorbed from the soil down-gradient of the wall. With the slow rate of groundwater flow in the area, this could continue for a prolonged period of time.

7.2 USEFUL LIFETIME OF THE PeRT WALLS

Existing PeRT walls at other sites have operated effectively for over 5 years. About 118 mg/L of Fe are expected to be released from the CCAS PeRT wall, most of which is likely to precipitate within the PeRT wall. At this rate of dissolution, the Fe^{+0} in a 4-inch wall will completely dissolve in about 1,000 years. The wall would become ineffective for degrading chlorinated VOCs to their MCLs prior to that time.

Conservative estimates of mineral precipitation suggest that over a 100 year period the following are maximum percentages of the available pore space that could be filled: carbonates, 20%; sulfides, 6%; and hydroxides, 17%. If these rates of mineral formation persist, porosity in the wall would decrease to zero in about 400 years and groundwater flow may be significantly diverted earlier. These estimates are preliminary and should be reevaluated after another year of groundwater monitoring.

7.3 EMPLACEMENT TECHNOLOGIES

Both emplacement techniques involved installing overlapping "panels" of iron. The walls emplaced in this pilot test were approximately four inches thick. To ensure continuity at the bottom of the treatment zone (45 feet bls), the maximum deviation allowable of any given overlapped panel was set at ¼ inches over 4 feet.

There were very few deviations noted in the mandrel emplacement. The equipment used was designed to install a wall of 60 foot depth. Based on the results of this pilot study, it is believed that a 60-foot depth installation could be achieved for a 4-inch thick wall, and greater depths would be possible for wider walls.

There were alignment difficulties with the JAG wall installation; however, deeper installation would be possible for thicker wall sections.

7.4 COMPARISON WITH GROUNDWATER PUMP AND TREAT

The capital cost of the PeRT wall installations is higher than a comparable groundwater "pump and treat" system. The cost estimate presented in Section 6.3 indicates that the O&M costs for the PeRT wall could be significantly less than groundwater pump and treat. Conservatively, the O&M savings could off-set the higher installation costs within four years following installation.

8.0 RECOMMENDATIONS

Additional monitoring and evaluation is recommended for a period of two years. The following sampling frequency and analyses are recommended:

- Quarterly samples for analysis of chlorinated VOCs
- Quarterly water levels
- Quarterly field chemistry, including ORP, pH, electrical conductivity, total and dissolved iron, hardness, dissolved oxygen and alkalinity
- Twice annually for common ions
- At least once for dissolved ethane, ethene and acetylene

It is recommended that additional monitoring wells be installed up-gradient of the wall so that samples can be collected and analyzed for chlorinated VOCs. This will be useful in determining the rate of natural attenuation of the chlorinated VOCs.

In the event the results are inconclusive after an additional two years of sampling, it is recommended that a pumping well be installed down-gradient of the walls. An aquifer pump test can then be performed to determine conclusively if the wall presents a barrier to groundwater flow.

Major-ion chemistry should be determined for some of the future sampling events. Major ion chemistry data can be used to calculate mineral saturation indices, information that can be used to predict the nature of mineral precipitates that could clog the wall.

An additional round of water levels should be measured to determine if the potential mounding phenomenon mentioned in Section 4 is a trend or merely a one-time anomaly. This should be done using an accurate water level measuring technique, such as chalked steel tape.

Continue downloading flow sensor data. The average period would need to be adjusted if more than one month's data is to be stored (say for quarterly downloads).

An evaluation of tidal influence be conducted at the Hangar K area to evaluate the magnitude of water level influence in all the aquifer zones of concern.

Collect soil samples from the two zones monitored (intermediate at 15 to 20 feet bls and deep at 35 to 40 feet bls) in the vicinity of the walls. Analyze soil samples VOCs. This will enable further evaluation of the potential for residual saturation skewing results.

Perform hydraulic conductivity tests on soils from the two zones. This will allow refinement of the hydraulic velocity calculations.

9.0 REFERENCES

AFCEE 1993. Department of the Air Force, Headquarters, Air Force Center for Environmental Excellence (AFCEE); Handbook for the Installation Restoration Program (IRP) Remedial Investigations and Feasibility Studies (RI/FS), September 1993.

AFCEE, 1996. Technical Protocols for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater. AFCEE, November 1996.

Ballard, 1998. "The In Situ Permeable Flow Sensor: A Ground-Water Flow Velocity Meter", Sanford Ballard, GROUNDWATER, Vol. 34, No. 2, March-April 1996.

Gavaskar, A. R., Gupta, N., Sass, B. M., Janosy, R. J., O'Sullivan, D., 1998. Permeable Barriers for Groundwater Remediation, Battelle Press, Columbus, Ohio, 176 pp.

Johnson, T. L., Scherer, M. M., and Tratnyek, P. G., 1996. Kinetics of Halogenated Organic Compound Degradation by Iron Metal, *Environ. Sci. Technol.*, v. 30, pp. 2634-2640.

Matheson, L. J. and Tratnyek, P. G., 1994. Reductive Dechlorination of Chlorinated Methanes by Iron Metal, *Environ. Sci. Technol.*, v. 28, pp. 2045-2053.

MSE, 1996 Analysis of Technologies for the Emplacement and Performance Assessment of Subsurface Reactive Barriers and DNAPL Containment, May 1996.

O'Hannesin, S. F. and Gillham, R. W., 1998. *Long-Term Performance of an In Situ "Iron Wall" for Remediation of VOCs*, Groundwater, v. 36, pp. 164-170.

Parsons ES, 1995. Preliminary Assessment #3, Preliminary Assessment and Field Sampling Strategy. Revision 1, October 1994. Revision 2, March 1995.

Parsons ES, 1996a. RCRA Facility Investigation/Corrective Measures Study Work Plan for Hangar K Area (DP-35), Hangar I (DP-34), Facility 1381 (DP-32), Facility 1798 (DP-48), Facility 49835 (DP-39), Facility 84920 (DP-33), September 1996.

Parsons ES, 1996b. Hydrogeologic Investigation of the Industrial Area Groundwater Investigation and Modeling Report, November 1996.

Powell, R. M. and Puls, R. W., 1997. *Proton Generation by Dissolution of Intrinsic or Augmented Aluminosilicate Minerals for in Situ Contaminant Remediation by Zero-Valent-State Iron*, Environ. Sci. Technol., v. 31, pp. 2244-2251.

Roberts, A.L., Tollen, L.A., Arnold, W.A., Burris, D.R., and Campbell, T. J. *Chlorinated Ethylenes by Zero-valent Metals*, Environ. Sci. Technol., v. 30, pp. 2654-2659.

Rust, 1997. Final Work Plan Prepared for Cape Canaveral Air Station, PeRT Wall Pilot Study. Revision 1, July 1997.

USAF IRP, 1995. United States Air Force Investigation Derived Waste Management Plan, 45th Space Wing Facilities at Cape Canaveral Air Station and Patrick Air Force Base, Florida, November 1995.

U.S. EPA, 1997. Permeable Reactive Subsurface Barriers for the Interception and Remediation of Chlorinated Hydrocarbons and Chromium (VI) Plumes in Groundwater, U.S. EPA Remedial Technology Fact Sheet. EPA/600/F-97/008, July 1997.

APPENDIX A

HISTORICAL MONITOR WELL CONSTRUCTION DETAILS

APPENDIX A
HISTORICAL MONITOR WELL CONSTRUCTION DETAILS
(Monitor Wells Installed prior to PeRT Wall Pilot Study)

Well ID	Installation Date	Ground Surface Elevation (msl)	Top of Casing Elevation (msl)	Borehole Depth (feet bls)	Well Depth (feet bls)	Screened Interval (feet bls)	Screened Interval (msl)			Well Type	Casing Diameter (inches)
Deep Wells											
1724MWD01	1/18/94	11.28	11.44	54.00	53.00	41.00 to 51.00	-29.56	to	-39.56	F	2.00
1740MWD02	12/6/94	8.83	8.83	37.00	37.00	25.00 to 35.00	-16.17	to	-26.17	F	2.00
1748DW1	10/20/92	9.57	9.00	35.00	35.00	25.00 to 35.00	-16	to	-26	F	2.00
1798MWD03	10/11/95	9.50	9.52	91.00	91.00	86.00 to 91.00	-76.48	to	-81.48	AG	2.00
49835MWD01	11/15/93	8.06	8.07	59.00	58.00	46.00 to 56.00	-37.93	to	-47.93	F	2.00
49835MWD04	11/16/93	6.92	9.76	44.00	43.00	31.00 to 41.00	-21.24	to	-31.24	AG	2.00
HGRIMWD02	11/7/93	8.72	11.52	45.00	44.00	32.00 to 42.00	-20.48	to	-30.48	AG	2.00
HGRIMWD03	11/6/93	10.44	10.28	46.00	45.00	33.00 to 43.00	-22.72	to	-32.72	F	2.00
IC0024	6/14/90	11.08	10.91	49.00	49.00	39.00 to 49.00	-28.09	to	-38.09	F	2.00
IC0025	6/13/90	8.81	8.97	46.00	46.00	33.50 to 46.00	-24.53	to	-37.03	F	2.00
IC0026	6/15/90	9.21	9.39	52.00	50.00	35.00 to 50.00	-25.61	to	-40.61	F	2.00
IC0027	6/15/90	8.84	8.77	53.00	51.00	36.00 to 51.00	-27.23	to	-42.23	F	2.00
IC0033	6/13/90	8.68	8.73	45.00	45.00	35.00 to 45.00	-26.27	to	-36.27	F	2.00
INDABOSA1	10/9/95	9.10	9.14	92.50	92.00	87.00 to 92.00	-77.86	to	-82.86	F	2.00
INDAMWD03	2/23/96	10.57	10.41	77.00	76.50	71.00 to 76.00	-60.59	to	-65.59	F	2.00
INDAMWD04	3/5/96	9.12	8.84	51.00	50.80	45.80 to 50.80	-36.96	to	-41.96	F	2.00
INDAMWD08	3/6/96	9.96	10.07	53.50	53.50	48.00 to 53.00	-37.93	to	-42.93	F	2.00
INDAMWD09	3/14/96	8.50	8.51	53.20	53.20	47.70 to 52.70	-39.19	to	-44.19	F	2.00
INDAMWD16	6/3/96	8.17	7.95	42.00	40.00	35.00 to 40.00	-27.05	to	-32.05	F	2.00
INDAMWDD16	9/11/96	8.12	7.83	56.00	54.00	49.00 to 54.00	-41.17	to	-46.17	F	2.00
INDAMWD17	6/5/96	9.53	9.09	44.00	43.00	38.00 to 43.00	-28.91	to	-33.91	F	2.00
INDAMWD22	2/12/97	9.89	9.68	50.50	50.00	45.00 to 50.00	-35.32	to	-40.32	F	2.00
Intermediate Wells											
1724MWD02	12/12/94	7.14	10.02	37.00	35.00	25.00 to 35.00	-14.98	to	-24.98	AG	2.00
INDAMWI04	3/5/96	8.99	9.02	34.00	34.00	29.00 to 34.00	-19.98	to	-24.98	F	2.00
INDAMWI16	5/20/96	8.23	7.74	33.00	33.00	28.00 to 33.00	-20.26	to	-25.26	F	2.00
INDAMWI17	5/28/96	9.44	9.23	34.00	34.00	29.00 to 34.00	-19.77	to	-24.77	F	2.00
INDAMWI22	2/12/97	9.87	9.59	33.50	32.50	27.50 to 32.50	-17.91	to	-22.91	F	2.00

APPENDIX A (Continued)

Well ID	Installati on Date	Ground Surface Elevation (msl)	Top of Casing Elevation (msl)	Borehole Depth (feet bls)	Well Depth (feet bls)	Screened Interval (feet bls)	Screened Interval (msl)			Well Type	Casing Diameter (inches)
Shallow Wells											
1724MWS01	1/21/94	11.28	11.32	17.00	16.50	4.50 to 14.50	6.82	to	-3.18	F	2.00
1724MWS02	6/13/94	6.70	10.10	12.00	12.00	2.00 to 12.00	8.1	to	-1.9	AG	2.00
1724MWS03	12/12/94	9.04	8.95	14.00	13.00	3.00 to 13.00	5.95	to	-4.05	F	2.00
1724MWS04	12/12/94	9.66	9.35	14.00	13.00	3.00 to 13.00	6.35	to	-3.65	F	2.00
1740MWS01	1/20/94	9.32	9.29	18.50	18.50	5.50 to 15.50	3.79	to	-6.21	F	2.00
1740MWS02	1/20/94	8.39	8.56	18.50	17.50	5.50 to 15.50	3.06	to	-6.94	F	2.00
1740MWS03	1/21/94	8.52	8.47	12.00	12.00	7.00 to 12.00	1.47	to	-3.53	F	2.00
1740MWS04	1/20/94	8.78	8.73	18.50	17.50	5.50 to 15.50	3.23	to	-6.77	F	2.00
1740MWS05	12/6/94	9.45	9.30	12.00	12.00	2.00 to 12.00	7.3	to	-2.7	F	2.00
1740MWS06	12/6/94	10.17	9.99	13.00	13.00	3.00 to 13.00	6.99	to	-3.01	F	2.00
1740MWS07	12/5/94	8.93	8.68	17.00	15.00	3.00 to 13.00	5.68	to	-4.32	F	2.00
1740MWS08	12/5/94	8.88	8.63	17.00	15.00	3.00 to 13.00	5.63	to	-4.37	F	2.00
1740MWS09	12/5/94	8.88	8.77	9.00	9.00	4.00 to 9.00	4.77	to	-0.23	F	2.00
1740MWS10	2/15/95	9.77	9.63	15.00	15.00	3.00 to 13.00	6.63	to	-3.37	F	2.00
1740MWS11	2/15/95	9.44	9.29	15.00	15.00	3.00 to 13.00	6.29	to	-3.71	F	2.00
1740MWS12	2/15/95	9.36	9.01	15.00	15.00	3.00 to 13.00	6.01	to	-3.99	F	2.00
1740MWS13	3/23/95	9.22	9.25	15.00	15.00	3.00 to 13.00	6.25	to	-3.75	F	2.00
1748MW1	10/19/92	8.94	8.85	12.00	12.00	2.00 to 12.00	6.85	to	-3.15	F	2.00
1748MW2	10/19/92	8.97	8.93	12.00	12.00	2.00 to 12.00	6.93	to	-3.07	F	2.00
1748MW3	10/19/92	8.60	8.54	12.00	12.00	2.00 to 12.00	6.54	to	-3.46	F	2.00
1748MW6	NA	9.15	9.09	12.00	12.00	2.00 to 12.00	7.09	to	-2.91	F	2.00
1748MW7	4/10/95	8.51	8.35	13.60	13.60	3.60 to 13.60	4.75	to	-5.25	F	2.00
1748MW8	4/10/95	9.57	9.43	13.60	13.60	3.60 to 13.60	5.83	to	-4.17	F	2.00
1748MW9	4/10/95	8.80	8.86	13.62	13.62	3.62 to 13.62	5.24	to	-4.76	F	2.00
55005CCDS703	1/4/89	9.28	12.31	NA	11.50	1.50 to 11.50	10.81	to	0.81	AG	2.00
60425TW01	12/4/92	9.34	9.30	11.00	11.00	6.00 to 11.00	3.3	to	-1.7	F	2.00
60425TW02	12/3/92	9.56	9.30	12.00	11.00	6.00 to 11.00	3.3	to	-1.7	F	2.00
60425TW03	1/14/93	9.83	9.68	11.50	10.50	5.50 to 10.50	4.18	to	-0.82	F	2.00
60425TW04	1/14/93	9.94	9.83	12.00	11.00	6.00 to 11.00	3.83	to	-1.17	F	2.00

APPENDIX A (Concluded)

Well ID	Installation Date	Ground Surface Elevation (msl)	Top of Casing Elevation (msl)	Borehole Depth (feet bls)	Well Depth (feet bls)	Screened Interval (feet bls)	Screened Interval (msl)			Well Type	Casing Diameter (inches)
IC0001	5/11/90	9.40	9.12	15.00	15.00	5.00 to 15.00	4.12	to	-5.88	F	2.00
IC0002	5/11/90	10.60	10.46	15.00	15.00	5.00 to 15.00	5.46	to	-4.54	F	2.00
IC0003	5/11/90	10.38	10.11	15.00	15.00	5.00 to 15.00	5.11	to	-4.89	F	2.00
IC0004	5/11/90	9.31	9.32	15.00	15.00	5.00 to 15.00	4.32	to	-5.68	F	2.00
IC0005	5/11/90	9.49	9.15	14.00	14.00	4.00 to 14.00	5.15	to	-4.85	F	2.00
IC0006	5/11/90	8.67	8.32	12.00	12.00	2.00 to 12.00	6.32	to	-3.68	F	2.00
IC0007	5/11/90	8.26	11.15	15.00	15.00	5.00 to 15.00	6.15	to	-3.85	AG	2.00
IC0008	5/11/90	9.40	9.16	14.00	14.00	4.00 to 14.00	5.16	to	-4.84	F	2.00
IC0009	5/11/90	9.91	9.71	14.00	14.00	4.00 to 14.00	5.71	to	-4.29	F	2.00
IC0010	5/11/90	9.08	8.89	14.00	14.00	4.00 to 14.00	4.89	to	-5.11	F	2.00
IC0013	5/30/90	10.74	10.74	14.00	14.00	4.00 to 14.00	6.74	to	-3.26	F	2.00
IC0014	5/30/90	11.14	11.05	15.00	15.00	5.00 to 15.00	6.05	to	-3.95	F	2.00
IC0015	5/30/90	8.62	10.84	12.00	12.00	2.00 to 12.00	8.84	to	-1.16	AG	2.00
IC0017	5/30/90	10.95	10.82	15.00	15.00	5.00 to 15.00	5.82	to	-4.18	F	2.00
IC0018	5/30/90	8.98	8.99	15.00	15.00	5.00 to 15.00	3.99	to	-6.01	F	2.00
IC0021	5/31/90	8.58	8.57	12.00	12.00	2.00 to 12.00	6.57	to	-3.43	F	2.00
IC0029	6/15/90	10.97	10.94	15.00	15.00	5.00 to 15.00	5.94	to	-4.06	F	2.00
IC0030	6/14/90	10.02	9.77	12.50	12.50	2.50 to 12.50	7.27	to	-2.73	F	2.00
IC0031	6/14/90	11.02	10.61	15.00	15.00	5.00 to 15.00	5.61	to	-4.39	F	2.00
IC0034	5/31/90	9.86	9.69	13.00	13.00	3.00 to 13.00	6.69	to	-3.31	F	2.00
IC0035	5/31/90	9.71	9.56	10.00	10.00	2.50 to 10.00	7.06	to	-0.44	F	2.00
IC0036	6/16/90	11.09	10.72	15.00	15.00	5.00 to 15.00	5.72	to	-4.28	F	2.00
IC0038	6/16/90	11.01	11.14	17.00	17.00	7.00 to 17.00	4.14	to	-5.86	F	2.00
INDAPZ02	11/9/95	9.02	10.67	8.50	8.50	3.50 to 8.50	7.17	to	2.17	AG	2.00

Notes:
AG - Above Ground Well Installation
F - Flush-Mount Well Installation
NA - Data Not Available

APPENDIX B

REPRESENTATIVE SOIL BORING LOGS

LIST OF TEST BORING REPORTS

HGRK-PRTMWD01
HGRK-PRTMWD03
HGRK-PRTMWD05
HGRK-PRTMWD07
HGRK-PRTMWD09
HGRK-PRTMWD11
HGRK-PRTMWD13
HGRK-PRTMWD15
HGRK-PRTMWD16
HGRK-PRTMWD17
HGRK-PRTMWD18

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD01

PROJECT: CCAS: Pert Wall Pilot Study
CLIENT: Cape Canaveral Air Station
CONTRACTOR: US Environmental
EQUIPMENT USED: D-120 with Hollow Stem Auger

JOB NO: 39748
PAGE NO: 1 OF 2
LOCATION: Hangar K
ELEVATION: ~8.9 feet
DATE START: 12/23/97
DATE FINISH: 12/23/97
DRILLER: T. Burke
PREPARED BY: C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.0'	SIZE ID			
					HAMMER WT		140 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
5					No sample collected from 5 foot interval.
		5			
10		10			SAND: Pale yellow (Hue2.5Y-7/4); loose; wet; high graded; fine to medium grained; rounded to subangular; slight trace of small shell fragments. OVA w/o filter 0 ppm
		21			
15		17			Zero recovery.
		24			
20		37			Silty SAND: Greenish gray (diagram1 for GLEY-6/1); medium dense; wet; high graded; fine grained; rounded. OVA w/o filter 3 ppm
		33			
25		61			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			BORING NO. HGRK-PRTMWD01
		+31	HARD	NR	NO RECOVERY			

TESTBOR 6/9/98 10:37

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					**Very Silty SAND:** Greenish gray (Diagram 1 for GLEY-5/1); dense; wet; high graded; fine grained; rounded; slight trace of small shell fragments. OVA w/o filter 2 ppm
		39			
30		60			**Sandy SILT:** Greenish gray (Diagram 2 for GLEY-5/1); dense; wet; high graded. OVA w/o filter 30 ppm OVA w/ filter 4 ppm
		8			
35		8			**SAND:** Dark olive brown (Hue 2.5Y-3/3); loose; wet; high graded; fine grained; rounded to subangular; trace of organic clay. OVA w/o filter 225 ppm OVA w/ filter 18 ppm
		31			
40		33			**Silty SAND:** Light gray (Hue 2.5Y-7/2); medium dense to dense; wet; high graded; fine grained; rounded; trace of small shell fragments. OVA w/o filter 450 ppm OVA w/ filter 50 ppm
45					
50					
55					Notes: (1) New charcoal (2) Greenish gray **Clayey SAND** encountered at ~34 feet BLS.

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD01
		+31	HARD	NR NO RECOVERY		

RUST ENVIRONMENT & INFRASTRUCTURE — TEST BORING REPORT

BORING NO. HGRK-PRTMWD03

PROJECT:	CCAS: Pert Wall Pilot Study
CLIENT:	Cape Canaveral Air Station
CONTRACTOR:	US Environmental
EQUIPMENT USED:	D-120 with Hollow Stem Auger

JOB NO:	39748
PAGE NO:	1 OF 2
LOCATION:	Hanger K
ELEVATION:	~8.8 feet
DATE START:	12/19/97
DATE FINISH:	12/19/97
DRILLER:	T. Burke
PREPARED BY:	C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.5'	SIZE ID			
					HAMMER WT		140 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
5					No sample collected from 5 foot interval.
		9			
10		22			SAND: Pale yellow (Hue 2.5Y-7/3); medium dense; wet; high graded; fine to medium grained; rounded to subangular; slight trace of small shell fragments. OVA w/o filter 0 ppm
		25			
15		36			SAND: Light yellowish brown (Hue 2.5Y-6/4); medium dense; wet; high graded; fine to medium grained; rounded to subangular; trace of small shell fragments. OVA w/o filter <1 ppm
		16			
20		33			Slightly Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); medium dense; wet; high graded; fine grained; rounded to subangular; slight trace of small shell fragments. OVA w/o filter 2 ppm
		30			
25		75			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			BORING NO. HGRK-PRTMWD03
		+31	HARD	NR	NO RECOVERY			

TESTBOR 6/9/98 10:38

RUST ENVIRONMENT & INFRASTRUCTURE TEST BORING REPORT

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine grained; rounded; slight trace of small shell fragments. OVA w/o filter 2 ppm
		28			
		43			
30					Sandy SILT: Greenish gray (Diagram 2 for GLEY-5/1); dense; wet; high graded; slight trace of small shell fragments. OVA w/o filter 180 ppm; OVA w/ filter 10 ppm
		11			
		13			
35					Clayey SAND: Grayish brown (Hue 10YR-5/2); loose; wet; high graded; fine grained; rounded; trace of small shell fragments; trace of clay stringers. OVA w/o filter 180 ppm; OVA w/ filter 8 ppm
		23			
		69			
40					Silty SAND: Light gray (Hue 2.5Y-7/2); dense; wet; high graded; fine grained; rounded; trace of small shell fragments. OVA w/o filter 100 ppm; OVA w/ filter 12 ppm
45					
50					
					Note: (1) Gray sandy SILT in tip of spoon at 40 feet.
55					

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			
		+31	HARD	NR	NO RECOVERY			

BORING NO. HGRK-PRTMWD03

RUST ENVIRONMENT & INFRASTRUCTURE — TEST BORING REPORT

BORING NO. HGRK-PRTMWD05

PROJECT:	CCAS: Pert Wall Pilot Study	**JOB NO:**	39748
CLIENT:	Cape Canaveral Air Station	**PAGE NO:**	1 OF 2
CONTRACTOR:	US Environmental	**LOCATION:**	Hanger K
EQUIPMENT USED:	D-120 with Hollow Stem Auger	**ELEVATION:**	~8.9 feet
		DATE START:	12/19/97
		DATE FINISH:	12/19/97
		DRILLER:	T. Burke
		PREPARED BY:	C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.5'	SIZE ID			
					HAMMER WT		140 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
5					No sample collected from 5 foot interval.
		8			
10		10			SAND: Light gray (Hue 2.5Y-7/2); loose; wet; high graded; fine to medium grained; rounded to subangular; slight trace of small shell fragments; slight trace of sandy limestone fragments. OVA w/o filter 55 ppm; OVA w/ filter 20 ppm
		9			
15		14			SAND: Light gray (Hue 2.5Y-7/2); loose; wet; high graded; fine to medium grained; rounded to subangular; trace of small shell fragments. OVA w/o filter 70 ppm; OVA w/ filter 26 ppm
		10			
20		10			Slightly Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); loose; wet; high graded; fine grained; rounded. OVA w/o filter 22 ppm
		13			
25		9			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			
		+31	HARD	NR	NO RECOVERY			

BORING NO. HGRK-PRTMWD05

TEST BORING REPORT

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					**Slightly Silty SAND:** Greenish gray (Diagram 1 for GLEY-6/1); loose; wet; high graded; fine grained; rounded; trace of shell fragments. OVA w/o filter 10 ppm
		13			
30		19			**Very Silty SAND:** Greenish gray (Diagram 2 for GLEY-5/1); loose to medium dense; wet; high graded; fine grained; rounded; slight trace of small shell fragments. OVA w/o filter 8 ppm
		13			
35		7			**Sandy CLAY:** Dark greenish gray (Diagram 2 for GLEY-4/1); loose; wet; high graded; medium plasticity; slight trace of small shell fragments. OVA w/o filter 90 ppm; OVA w/ filter 11 ppm
		5			
40		25			**Silty SAND:** Greenish gray (Diagram 1 for GLEY-5/1); medium dense; wet; high graded; fine grained; rounded; trace of clay content; trace of small shell fragments. OVA w/o filter 140 ppm; OVA w/ filter 14 ppm
45					
50					
55					Notes: (1) New charcoal (2) Medium clay beginning @ 34.5 feet

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD05
		+31	HARD	NR NO RECOVERY		

RUST ENVIRONMENT & INFRASTRUCTURE TEST BORING REPORT

BORING NO. HGRK-PRTMWD07

PROJECT:	CCAS: Pert Wall Pilot Study
CLIENT:	Cape Canaveral Air Station
CONTRACTOR:	US Environmental
EQUIPMENT USED:	D-120 with Hollow Stem Auger

JOB NO:	39748
PAGE NO:	1 OF 2
LOCATION:	Hanger K
ELEVATION:	~8.9 feet
DATE START:	12/19/97
DATE FINISH:	12/19/97
DRILLER:	T. Burke
PREPARED BY:	C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.5'	SIZE ID			
					HAMMER WT		140 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
5					No sample collected from 5 foot interval.
		17			
10		22			SAND: Light gray (Hue 2.5Y-7/2); medium dense; wet; high graded; fine to medium grained; rounded to subangular; trace of sandy limestone fragments; trace of small shell fragments. OVA w/o filter 65 ppm OVA w/ filter 6 ppm
		21			
15		45			SAND: Light greenish gray (Diagram 1 for GLEY-7/1); medium dense to dense; wet; high graded; fine to medium grained; rounded to subangular; little shell fragments. OVA w/o filter 60 ppm OVA w/ filter 20 ppm
		27			
20		51			Slightly Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine grained; rounded; slight trace of small shell fragments. OVA w/o filter 6 ppm
		16			
25		32			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			BORING NO. HGRK-PRTMWD07
		+31	HARD	NR	NO RECOVERY			

TESTBOR 6/9/98 10:30

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD07

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); medium dense; wet; high graded; fine to very fine grained; rounded; slight trace of shell fragments. OVA w/o filter 15 ppm
		34			
		65			
30					Very Silty SAND: Greenish gray (Diagram 2 for GLEY-5/1); dense; wet; high graded; fine to very fine grained; rounded. OVA w/o filter 13 ppm
		29			
		24			
35					Clayey SAND: Greenish gray (Diagram 2 for GLEY- 5/1); medium dense; wet; high graded; fine grained; rounded; trace of shell fragments. OVA w/o filter 125 ppm OVA w/ filter 11 ppm
		21			
		68			
40					Silty SAND: Light greenish gray (Diagram 1 for GLEY-7/1); dense; wet; high graded; fine grained; rounded to subangular; trace of small shell fragments. OVA w/o filter 225 ppm OVA w/ filter 30 ppm
45					
50					
55					Notes: (1) New charcoal (2) Medium dense clay noted at 34.5 feet.

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD07
		+31	HARD	NR NO RECOVERY		

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD09

PROJECT:	CCAS: Pert Wall Pilot Study	JOB NO:	39748
CLIENT:	Cape Canaveral Air Station	PAGE NO:	1 OF 2
CONTRACTOR:	US Environmental	LOCATION:	Hanger K
EQUIPMENT USED:	D-120 with Hollow Stem Auger	ELEVATION:	~8.9 feet
		DATE START:	12/17/97
		DATE FINISH:	12/17/97
		DRILLER:	T. Burke
		PREPARED BY:	C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.4'	SIZE ID			
					HAMMER WT		140 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
					No samples collected for OVA screening. OVA inoperable.
5					No sample collected from 5 foot interval.
		19			
10		41			SAND: Light gray (Hue 2.5Y-7/1); medium dense; wet; high graded; fine to medium grained; rounded to subangular; slight trace of small shell fragments.
		28			
15		52			SAND: Light greenish gray (Diagram 1 for GLEY-7/1); dense; wet; high graded; fine grained; rounded to subangular; trace of small shell fragments; trace of silt.
		28			
20		72			Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine grained; rounded; slight trace of small shell fragments.
		34			
25		51			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			BORING NO. HGRK-PRTMWD09
		+31	HARD	NR	NO RECOVERY			

TESTBOR 8/8/98 10:39

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD09

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine grained; rounded; slight trace of small shell fragments.
		32			
		42			
30					Slightly Clayey, Silty SAND: Greenish gray (Diagram 2 for GLEY-6/1); dense; wet; high graded; very fine grained; rounded; slight trace of small shell fragments.
		7			
		5			
35					SAND: Dark olive brown (Hue 2.5Y-3/3); loose; wet; high graded; fine grained; rounded to subangular; trace of slightly fibrous organic material; slight trace of organic clay; slight trace of small shell fragments.
		11			
		51			
40					Silty SAND: Greenish gray (Diagram 1 for GLEY 6/1); dense; wet; high graded; fine grained; rounded to subangular; trace of slightly calcareous clay; slight trace of small shell fragments.
45					
50					
55					

Notes: (1) Clayey SAND observed at approximately 34 feet.
(2) Stiff CLAY noted in tip of spoon at 40 feet.
(3) At 30 feet, augers deflected off something and angled northerly (towards building).

BLOWS/FT.	DENSITY
0-4	VERY LOOSE
5-10	LOOSE
11-30	MEDIUM DENSE
31-50	DENSE
51+	VERY DENSE

BLOWS/FT.	CONSISTENCY
0-2	VERY SOFT
3-4	SOFT
5-8	MEDIUM STIFF
9-15	STIFF
16-30	VERY STIFF
+31	HARD

SAMPLE ID	
S	SPLIT SPOON
T	TUBE
U	UNDISTURBED PISTON
G	GRAB SAMPLE
X	OTHER
NR	NO RECOVERY

COMPONENT %	
MOSTLY	50-100%
LITTLE	15-25%
FEW	5-10%
TRACE	<5%

GROUND WATER ABBREV.
- WD - WHILE DRILLING
- NE - NOT ENCOUNTERED
- UR - NOT READ

BORING NO. HGRK-PRTMWD09

RUST ENVIRONMENT & INFRASTRUCTURE	TEST BORING REPORT	BORING NO. HGRK-PRTMWD11

PROJECT:	CCAS: Pert Wall Pilot Study	JOB NO:	39748
CLIENT:	Cape Canaveral Air Station	PAGE NO:	1 OF 2
CONTRACTOR:	US Environmental	LOCATION:	Hanger K
EQUIPMENT USED:	D-120 with Hollow Stem Auger	ELEVATION:	~9.0 feet
		DATE START:	12/17/97
		DATE FINISH:	12/17/97
		DRILLER:	T. Burke
		PREPARED BY:	C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~39.8'	SIZE ID			
					HAMMER WT		140 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
					No samples collected for OVA samples; OVA inoperable.
5					No sample collected from 5 foot interval.
		13			
10		23			<u>SAND:</u> Pale yellow (Hue 2.5Y-7/3); medium dense; wet; high graded; fine to medium grained; rounded to angular; slight trace of small shell fragments.
		15			
15		29			<u>Silty SAND:</u> Light greenish gray (Diagram 1 for GLEY-7/1); medium dense; wet; high graded; fine grained; trace of small shell fragments.
		32			
20		62			<u>SAND:</u> Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine to medium grained; rounded to subangular; trace of silt; trace of small shell fragments.
		38			
25		74			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			BORING NO. HGRK-PRTMWD11
		+31	HARD	NR	NO RECOVERY			

TESTBOR 6/9/98 10:39

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD11

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					<u>Silty SAND:</u> Greenish gray (Diagram 2 for GLEY-6/1); dense; wet; high graded; fine grained; rounded to subangular; slight trace of shell fragments.
		34			
		32			
30					<u>Clayey SILT:</u> Greenish gray (Diagram 2 for GLEY-5/1); dense; wet; high graded; trace of fine silica sand.
		9			
		11			
35					<u>SAND:</u> Very dark brown (Hue 7.5YR-2.5/2); loose; wet; high graded; fine grained; rounded to subangular; trace of colloidal organic material.
		23			
		62			
40					<u>Silty SAND:</u> Light gray (Hue 2.5Y-7/2); dense; wet; high graded; fine grained; rounded to subangular; trace of small shell fragments.
45					
50					
55					Note: (1) In tip of spoon at 40 feet, encountered bluish gray clayey SAND.

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			BORING NO. HGRK-PRTMWD11
		+31	HARD	NR	NO RECOVERY			

TESTBOR 6/9/96 10:39

RUST ENVIRONMENT & INFRASTRUCTURE — TEST BORING REPORT

BORING NO. HGRK-PRTMWD13

PROJECT:	CCAS: Pert Wall Pilot Study	**JOB NO:**	39748
CLIENT:	Cape Canaveral Air Station	**PAGE NO:**	1 OF 2
CONTRACTOR:	US Environmental	**LOCATION:**	Hanger K
EQUIPMENT USED:	D-120 with Hollow Stem Auger	**ELEVATION:**	~9.0 feet
		DATE START:	12/17/97
		DATE FINISH:	12/17/97
		DRILLER:	T. Burke
		PREPARED BY:	C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.2'	SIZE ID			
					HAMMER WT		140 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
5					No sample collected from 5 foot interval.
		12			
10		28			<u>SAND:</u> Light gray (Hue 2.5Y-7/2); medium dense; wet; high graded; medium to fine grained; rounded to subangular; trace of small shell fragments. OVA w/o filter 3.5 ppm
		20			
15		46			<u>SAND:</u> Light greenish gray (Diagram 1 for GLEY-7/1); medium dense to dense; wet; high graded; fine to medium grained; rounded to angular; trace of small shell fragments; trace of silt. OVA w/o filter 20 ppm OVA w/ filter 7 ppm
		16			
20		37			<u>Silty SAND:</u> Greenish gray (Diagram 1 for GLEY-6/1); medium dense; wet; high graded; fine grained; rounded to subangular; trace of small shell fragments. OVA w/o filter 5 ppm
		23			
25		45			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			**BORING NO. HGRK-PRTMWD13**
		+31	HARD	NR	NO RECOVERY			

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD13

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					**Silty SAND:** Greenish gray (Diagram 2 for GLEY-6/1); medium dense to dense; wet; high graded; very fine grained; rounded; slight trace of small shell fragments. OVA w/o filter 1 ppm
		10			
		10			
30					**Very Sandy CLAY:** Greenish gray (Diagram 2 for GLEY- 5/1); loose; wet; high graded; medium plasticity; slight trace of small shell fragments. OVA w/o filter 50 ppm OVA w/ filter 5 ppm
		2			
		5			
35					**Clayey SAND:** Greenish gray (Diagram 2 for GLEY-5/1); very loose; wet; high graded; fine grained; rounded; slight trace of small shell fragments. OVA w/o filter 160 ppm OVA w/ filter 4 ppm
		43			
		50			
40					**Silty SAND:** Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine grained; rounded to subangular; trace of small shell fragments. OVA w/o filter 225 ppm OVA w/ filter 5 ppm
45					
50					
55					Note: (1) New charcoal (2) 2 inch layer of clay at approximately 33 feet.

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD13
		+31	HARD	NR NO RECOVERY		

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD15

PROJECT:	CCAS: Pert Wall Pilot Study	JOB NO:	39748
CLIENT:	Cape Canaveral Air Station	PAGE NO:	1 OF 2
CONTRACTOR:	US Environmental	LOCATION:	Hanger K
EQUIPMENT USED:	D-120 with Hollow Stem Auger	ELEVATION:	~9.0 feet
		DATE START:	12/16/97
		DATE FINISH:	12/17/97
		DRILLER:	T. Burke
		PREPARED BY:	C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.4'	SIZE ID			
					HAMMER WT		180 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
					No OVA samples collected from 10 to 25 feet; OVA inoperable.
5					No sample collected from 5 foot interval.
		7			
10		10			**SAND:** Light gray (Hue 2.5Y-7/2); loose; wet; high graded; fine to medium grained; rounded to subangular; trace of small shell fragments.
		9			
15		12			**Silty SAND:** Greenish gray (Diagram 1 for GLEY-6/1); loose; wet; high graded; very fine graded; rounded.
		21			
20		24			**Silty SAND:** Greenish gray (Diagram 1 for GLEY-6/1); medium dense; wet; high graded; very fine graded; rounded; slight trace of small shell fragments.
25					

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			BORING NO. HGRK-PRTMWD15
		+31	HARD	NR	NO RECOVERY			

TESTBOR 6/9/98 10:40

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD15

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					Heaving sands at 25 feet (moving to another hole to allow to stabilize). On 12/16 and 12/17; heaving sands prevented collecting soils from this interval.
		5			
30		6			Very Sandy CLAY: Greenish gray (Diagram 2 for GLEY-5/1); loose; wet; high graded; medium plasticity; slight trace of shell fragments. OVA w/o filter 50 ppm Ova w/ filter 2 ppm
		5			
35		18			SAND: Very dark brown (Hue 7.5YR-2.5/2); medium dense; wet; high graded; fine grained; rounded to subangular; trace of colloidal organic material OVA w/o filter 250 ppm OVA w/ filter 5 ppm.
		18			
40		72			Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine grained; rounded to subangular; trace of small shell fragments. OVA w/o filter 175 ppm OVA w/ filter 5 ppm
45					
50					
55					Notes: (1) New charcoal (2) 2 inch layer of clay at 34 feet.

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD15
		+31	HARD	NR NO RECOVERY		

TESTBOR 6/9/98 10:40

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD16

PROJECT: CCAS: Pert Wall Pilot Study
CLIENT: Cape Canaveral Air Station
CONTRACTOR: US Environmental
EQUIPMENT USED: D-120 with Hollow Stem Auger

JOB NO: 39748
PAGE NO: 1 OF 2
LOCATION: Hanger K
ELEVATION: ~9.0 feet
DATE START: 12/16/97
DATE FINISH: 12/16/97
DRILLER: T. Burke
PREPARED BY: C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~39.7'	SIZE ID			
					HAMMER WT		180 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
					No OVA samples collected from 25 to 40 feet; OVA inoperable.
5					No sample collected from 5 foot interval.
		5			
10		17			SAND: Light brownish gray (2.5Y-6/2); medium dense; wet; high graded; fine to medium grained; rounded to angular; slight trace of small shell fragments. OVA w/o filter 7 ppm
		32			
15		37			Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; very fine grained; rounded. OVA w/o filter 3 ppm
		12			
20		26			SAND: Greenish gray (Diagram 1 for GLEY-6/1); medium dense; wet; high graded; fine to medium grained; angular to subangular; trace of small shell fragments. OVA w/o filter 8 ppm
		24			
25		31			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD16
		+31	HARD	NR NO RECOVERY		

TEST BORING REPORT

BORING NO. HGRK-PRTMWD16

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					SAND: Greenish gray (Diagram 1 for GLEY-6/1); medium dense; wet; high graded; fine to medium grained; angular to subangular; trace of small shell fragments.
		22			
		27			
30					Silty SAND: Greenish gray (Diagram 2 for GLEY-6/1); medium dense; wet; high graded; fine grained; rounded; slight trace of small shell fragments.
		7			
		15			
35					Silty SAND: Greenish gray (Diagram 1 for GLEY-6/1); loose; wet; high graded; fine grained; rounded to subangular; trace of small shell fragments.
		29			
		43			
40					SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine grained; rounded to subangular; little small shell fragments; trace of silt.
45					
50					
55					Note: (1) Heaving sands encountered near 25 feet BLS.

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD16
		+31	HARD	NR NO RECOVERY		

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD17

PROJECT: CCAS: Pert Wall Pilot Study
CLIENT: Cape Canaveral Air Station
CONTRACTOR: US Environmental
EQUIPMENT USED: D-120 with Hollow Stem Auger

JOB NO: 39748
PAGE NO: 1 OF 2
LOCATION: Hanger K
ELEVATION: ~9.0 feet
DATE START: 12/16/97
DATE FINISH: 12/16/97
DRILLER: T. Burke
PREPARED BY: C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.0'	SIZE ID			
					HAMMER WT		140 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
5					No sample collected from 5 foot interval.
		32			
10		48			SAND: Light brownish gray (Hue 2.5Y-6/2); dense; wet; high graded; fine to medium grained; rounded to angular; slight trace of small shell fragments. OVA w/o filter 4 ppm
		51			
15		63			SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; very fine grained; rounded; slight trace of small shell fragments. OVA w/o filter 5 ppm
		11			
20		48			SAND: Greenish gray (Diagram 2 for GLEY-6/1); dense; wet; high graded; fine to medium grained; angular to subangular; slight trace of shell fragments. OVA w/o filter 2 ppm
		29			
25		61			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD17
		+31	HARD	NR NO RECOVERY		

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD17

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
25					20% recovery; no sample described. OVA w/o filter 2 ppm
		13			
30		13			Clayey SAND: Greenish gray (Diagram 2 for GLEY-6/1); medium dense; wet; high graded; very fine grained; rounded; trace of silt; slight trace of shell fragments. OVA w/o filter 140 ppm OVA w/ filter 3 ppm
		9			
35		19			SAND: Very dark brown (Hue 7.5YR-2.5/2); medium dense; wet; high graded; fine grained; rounded to subangular; trace of colloidal organic material. OVA w/o filter 175 ppm OVA w/ filter 4 ppm
		31			
40		39			SAND: Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine grained; rounded; trace of silt; little small shell fragments. OVA w/o filter 175 ppm OVA w/ filter 3 ppm
45					
50					
55					Note: (1) New charcoal

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID	COMPONENT %	GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S SPLIT SPOON	MOSTLY 50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T TUBE	LITTLE 15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U UNDISTURBED PISTON	FEW 5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G GRAB SAMPLE	TRACE <5%	
51+	VERY DENSE	16-30	VERY STIFF	X OTHER		BORING NO. HGRK-PRTMWD17
		+31	HARD	NR NO RECOVERY		

RUST ENVIRONMENT & INFRASTRUCTURE — TEST BORING REPORT

BORING NO. HGRK-PRTMWD18

PROJECT:	CCAS: Pert Wall Pilot Study	**JOB NO:**	39748
CLIENT:	Cape Canaveral Air Station	**PAGE NO:**	1 OF 2
CONTRACTOR:	US Environmental	**LOCATION:**	Hanger K
EQUIPMENT USED:	D-120 with Hollow Stem Auger	**ELEVATION:**	~9.0 feet
		DATE START:	12/13/97
		DATE FINISH:	12/13/97
		DRILLER:	T. Burke
		PREPARED BY:	C. Jackson

GROUND WATER		DEPTH TO:				CASING	SAMPLER	CORE BARREL
DATE	HRS AFTER COMP	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	TYPE		S	
		~5'		~40.1'	SIZE ID			
					HAMMER WT		180 lbs.	
					HAMMER FALL		30 inch	

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE	FIELD CLASSIFICATION AND REMARKS
		14			
5		28			**SAND:** White (Hue 2.5Y-8/1); medium dense; wet; high graded; fine to medium grained; angular to subangular. OVA w/o filter <1.0 ppm
		20			
10		49			**SAND:** Light gray (Hue 2.5Y-7/2); medium dense to dense; wet; high graded; fine to medium grained; angular to subangular; trace of small shell fragments. OVA w/o filter 3.0 ppm
		40			
15		83			**SAND:** Light gray (Hue 2.5Y-7/1); dense; wet; high graded; fine to medium grained; angular; trace of small shell fragments. OVA w/o filter 4.0 ppm
		22			
20		59			**SAND:** Greenish gray (Diagram 1 for GLEY-6/1); dense; wet; high graded; fine to medium grained; rounded to subangular; trace of small shell fragments. OVA w/o filter 4.0 ppm
		22			
25		43			

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY	SAMPLE ID		COMPONENT %		GROUND WATER ABBREV.
0-4	VERY LOOSE	0-2	VERY SOFT	S	SPLIT SPOON	MOSTLY	50-100%	WD - WHILE DRILLING
5-10	LOOSE	3-4	SOFT	T	TUBE	LITTLE	15-25%	NE - NOT ENCOUNTERED
11-30	MEDIUM DENSE	5-8	MEDIUM STIFF	U	UNDISTURBED PISTON	FEW	5-10%	UR - NOT READ
31-50	DENSE	9-15	STIFF	G	GRAB SAMPLE	TRACE	<5%	
51+	VERY DENSE	16-30	VERY STIFF	X	OTHER			BORING NO. HGRK-PRTMWD18
		+31	HARD	NR	NO RECOVERY			

TESTBOR 6/9/98 10:41

RUST ENVIRONMENT & INFRASTRUCTURE

TEST BORING REPORT

BORING NO. HGRK-PRTMWD18

DEPTH IN FEET	CASING BLOWS PER FOOT	SAMPLER BLOWS PER FOOT	SAMPLE NUMBER	SAMPLE DEPTH RANGE
25				
		11		
		18		
30				
		7		
		18		
35				
		19		
		40		
40				
45				
50				
55				

FIELD CLASSIFICATION AND REMARKS

Silty SAND: Greenish gray (Diagram 2 for GLEY-6/1); medium dense; wet; high graded; fine grained; rounded; trace of small shell fragments; slight trace of clay stringers.
OVA w/o filter 5.0 ppm

Clayey SILT: Greenish gray (Diagram 2 for GLEY-5/1); loose; wet; high graded; trace of shell fragments.
OVA w/o filter 150 ppm
OVA w/ filter 4.0 ppm

Slightly Clayey SAND: Greenish gray (Diagram 2 for GLEY-5/1); loose; wet; high graded; fine grained; rounded; trace of small shell fragments.
OVA w/o filter 400 ppm

Silty SAND: Greenish gray (Diagram 1 for GLEY-5/1); medium dense; wet; high graded; fine grained; rounded; little small shell fragments.
OVA w/o filter 400 ppm
OVA w/ filter 8.0 ppm

Notes: (1) New charcoal
(2) Possible slight trace of iron shavings detected 20 feet BLS sample.

BLOWS/FT.	DENSITY
0-4	VERY LOOSE
5-10	LOOSE
11-30	MEDIUM DENSE
31-50	DENSE
51+	VERY DENSE

BLOWS/FT.	CONSISTENCY
0-2	VERY SOFT
3-4	SOFT
5-8	MEDIUM STIFF
9-15	STIFF
16-30	VERY STIFF
+31	HARD

SAMPLE ID	
S	SPLIT SPOON
T	TUBE
U	UNDISTURBED PISTON
G	GRAB SAMPLE
X	OTHER
NR	NO RECOVERY

COMPONENT %	
MOSTLY	50-100%
LITTLE	15-25%
FEW	5-10%
TRACE	<5%

GROUND WATER ABBREV.
WD - WHILE DRILLING
NE - NOT ENCOUNTERED
UR - NOT READ

BORING NO. HGRK-PRTMWD18

APPENDIX C

ANALYTICAL DATA SUMMARY REPORT

1.0 DATA VALIDATION INTRODUCTION

Groundwater sampling activities in support of monitoring the Permeable Reactive Treatment (PeRT) Wall at the Cape Canaveral Air Station (CCAS) were conducted monthly from February through November 1998. Samples were collected quarterly in February, May, August, and November 1998 for laboratory analysis of volatile organic compounds (VOCs). This data validation report addresses the data quality of the quarterly samples analyzed for VOCs.

Rust Environment & Infrastructure (Rust) has performed independent quality control (QC) checks of the field and laboratory procedures that were used in collecting and analyzing the data collected at Cape Canaveral Air Station during 1998. The QC checks verify that the data collected are of appropriate quality for the intended data use and that the data quality objectives (DQOs) were met. The analytical procedures were evaluated with respect to guidelines adapted from the most current editions of Test Methods for Evaluating Solid Waste-Physical/Chemical Methods, EPA/SW-846, 3rd Edition (1986) and Update III (1996), and the Air Force Center for Environmental Excellence (AFCEE) Quality Assurance Project Plan (QAPP), Version 2.0 (AFCEE, January 1997) and updates to Version 2.0 dated 25 February, 1997. Analytical results were validated based on a review of custody information, method blanks, laboratory single control samples and duplicate control samples (SCS/DCS), surrogate spikes, and matrix spike/matrix spike duplicates (MS/MSD). The field activities and laboratory procedures are discussed in the following sections.

2.0 ASSESSMENT OF DATA QUALITY INDICATORS

The assessment of the data quality indicators determines the data usability. The assessment of data quality indicators for either sampling or analysis involves the evaluation of five indicators: precision, accuracy, representativeness, completeness, and comparability. The indicators are commonly referred to as the PARCC parameters.

Precision is a measure of the repeatability of measurements under a given set of conditions. Specifically, it is the quantitative measure of the variability of a group of measurements

compared to the average value. The overall precision of measurement data is a mixture of sampling and analytical factors and is evaluated from the results of duplicate samples. Poor precision can result from poor instrument performance, inconsistent method protocols, or difficult, heterogeneous sample matrix. Analytical precision is much easier to control and quantify than sampling precision. The analytical results from laboratory DCS and MSD samples provide data on analytical precision. The analytical results from field duplicate samples provide data on sampling precision. These samples provide relative percent difference (RPD) data that can be used to review the precision in sampling and analytical activities.

Accuracy measures the bias in a measurement system. Accuracy is difficult to measure for the entire data collection activity. Sampling accuracy is influenced by the sample collection process, sample handling, preparation and preservation procedures, field contamination, and sample matrix. A review of cooler temperature, sample pH, sample holding time, and trip blank results provide information about sampling accuracy. Analytical accuracy is assessed through use of known and unknown QC samples and spike samples. Accuracy determinations by known samples include the use of laboratory SCS, laboratory method blanks, and split samples. Analytical accuracy determinations by unknown samples include the analysis of MS samples and surrogate spikes. These samples provide percent recovery results that can be used to determine the effects of sample matrix and laboratory methodology on analytical accuracy.

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling program. Sampling representativeness is best achieved by making certain that sampling locations are selected properly and a sufficient number of samples are collected. Analytical representativeness can be determined by review of laboratory method blanks. Laboratory method blanks are used to ensure that sample results (clean or contaminated) are representative of site conditions and not laboratory conditions.

Completeness is defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is essentially the same for all data uses: that a sufficient amount of valid data be generated. It is important that critical samples are collected and valid data achieved. A change in the number of samples collected from the number specified in a work plan can affect the sampling completeness. Analytical completeness is defined as the number of chemical-specific data results that are determined acceptable after data review.

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through using standard techniques to collect and analyze representative samples and reporting analytical results in appropriate units. Comparability is limited to other PARCC parameters because only when precision and accuracy are known can data sets be compared with confidence.

3.0 FIELD SAMPLING ACTIVITIES

Groundwater sampling activities at Cape Canaveral Air Station were conducted in February, May, August, and November 1998. The major activity in determining the usability of data based on sampling is assessing the effectiveness of the sampling operations performed.

Sampling precision was monitored through the use of field duplicate samples. Duplicates were collected at a rate of approximately one per ten samples. Comparison of the duplicate sample to the primary sample was performed by calculating the RPD as follows:

$$RPD = [(A-B)/((A+B)/2)] * 100$$

Where: A = Result of Primary Sample

B = Result of Duplicate Sample

A RPD was not calculated if a data set contained an estimated value (data qualified with "J"). The data qualifier "/A" was added to sample results in cases when the RPD between the primary and duplicate sample was above review guidelines.

Holding times, sample preservation, trip blanks, and equipment rinsate blanks provide information regarding the sampling accuracy. The sampling holding time guidelines used during validation procedures are those established in EPA Test Methods for Evaluating Solid Waste (SW-846), 3rd Edition (1986) and Update III (1996). All samples collected for VOC analyses were analyzed within the established holding time limit and no data qualifiers were required.

Representativeness is primarily a planning concern and is addressed in the design of a sampling

plan that is deemed representative of the project objectives. Other indicators of representativeness are the trip blank, the ambient field blank, and the equipment rinsate blank. Trip blanks are vials of certified clean water which are transported with the sample from sample collection to log-in at the laboratory to sample analysis. Contamination detected in the trip blank may be an indication that the integrity of the sample has been compromised during shipping and handling or storage of the samples. Sample results flagged with a "/T" indicate the parameter was detected in the associated trip blank. Results for trip blank samples are provided on the attached data summary tables.

An equipment rinsate blank is a sample of certified clean water that was used as a final rinse during the decontamination of sampling equipment. Contamination detected in an equipment rinsate blank may be an indication that the integrity of a sample has been compromised through the use of poorly decontaminated field equipment. Sample results flagged with a "/V" indicate the parameter was detected in the associated equipment rinsate blank. Results for equipment rinsate blank samples are provided on the attached data summary tables.

Ambient field blanks are vials of certified clean water which are taken into the field and exposed to the ambient conditions at the site during collection of a site sample. Contamination detected in the ambient field blank may be an indication that the integrity of the sample has been affected through exposure to the atmosphere during the sampling process. Analytical results flagged with a "/F" indicate the parameter was detected in the associated ambient field blank. Results for contaminants detected in field blank samples are provided on the attached data summary tables.

The measure of completeness is useful for data collection and analysis management. Any decrease in the number of samples specified in the project work plans may the final results. All samples were collected as specified in the associated project work plan.

Comparability issues have little impact on performance measures associated with sampling provided that the sample design is unbiased, and the sample design or analytical methods have not changed over time. Comparability was achieved by following the sample design as described in the project work plans. The field sampling activities were performed as specified in the associated project work plan.

4.0 ANALYTICAL LABORATORY PROCEDURES

The purpose of this section is to provide a data validation summary of the analytical procedures performed at the off-site laboratory Kemron Environmental Services (Kemron). The QC procedures performed at Kemron included method blanks, SCS/DCS, MS/MSD, and surrogate spikes. Determining the usability of analytical results begins with the review of QC samples and data acceptance criteria. The review is used to determine an overall assessment of analytical performance as determined by the laboratory and method performance.

4.1 Method Blanks

Analytical representativeness involves the review of laboratory method blanks. As discussed in the Contract Laboratory Program (CLP) Statement of Work (SOW) for Organics Analysis (EPA, 1991) and the National Functional Guidelines for Organic Data Review (1994), acetone, 2-butanone (methyl ethyl ketone), and methylene chloride are considered to be common laboratory contaminants. In accordance with the EPA data review guidelines, site sample results of common laboratory artifacts should be considered positive results (i.e., site-related) only if the concentrations in the site sample exceed ten times the maximum amount detected in any associated blank. If the blank contains detectable levels of one or more chemicals not considered common laboratory contaminants, then site sample results are considered positive only if the concentration in the site sample exceeds five times the maximum amount detected in any associated blank. Only those results indicating concentrations exceeding the blank concentration determined by the five or ten times rules, as appropriate, are considered to be potentially site-related.

In evaluating the blank samples, an "/L" flag was added to sample results in which common laboratory contaminants were identified at levels less than ten times the amount detected in the corresponding blank or less than five times the amount detected in the corresponding blank for all other contaminants. This "/L" flag indicates that the detection is not site-related per the EPA blank evaluation criteria discussed above. Sample results containing common laboratory artifacts detected at a concentration greater than ten times that detected in the associated blank or some other contaminant detected at a concentration greater than five times that detected in the associated blank are flagged with a "/K". Professional judgment must be used to determine if the detected compound is site related.

4.2 Surrogate Spikes

All samples analyzed for VOCs were spiked with surrogate compounds as a measure of accuracy in regard to matrix interference. In accordance with data review guidelines, detections of organic compounds in a sample were qualified "/T" when the surrogate had a recovery greater than the upper acceptance limit (to indicate bias high). No data qualifier was added when a surrogate had a percent recovery exceeding the upper or lower limit by a value of one.

4.3 Laboratory Control Samples

In cases when the laboratory single control sample percent recovery was less than the lower limit, the data qualifiers "/Jc" were assigned to all sample detects, and the data qualifiers "/Rc" were assigned to all sample non-detects for the associated compounds. If more than half of the compounds in the laboratory single control sample were not within the percent recovery limits, the data qualifier "/J" was assigned to all sample detects, and the data qualifier "/R" was assigned to all sample non-detects of the associated compounds.

4.4 Matrix Spike/Matrix Spike Duplicates

MS/MSD samples were analyzed for each laboratory batch. MS/MSDs are generated to determine long-term precision and accuracy of the analytical method on various matrices and to demonstrate acceptable compound recovery by the laboratory at the time of sample analysis. The MS is used to evaluate the effect of the sample matrix on the accuracy of the analysis. The MSD samples are processed separately and the results compared to determine the effects of the matrix on the precision and accuracy of the analysis. Results are expressed as percent recovery and RPD. In cases when the percent recovery of the MS sample was below the established criteria, the data qualifier "/m" was assigned to the detect or non-detect of the specific parameter in the associated parent sample. However, these data alone cannot be used to evaluated the precision and accuracy of individual samples.

4.5 Completeness

The completeness for analytical data is defined as the number of chemical-specific data results that are determined acceptable after data review. Sample results that should be considered estimated values after validation review were flagged "J". Approximately 1.3% of all analytical results were assigned the data qualifier "J". Sample results that have been determined to be unacceptable after validation review were flagged with the "R" qualifier. Approximately 0.6% of all analytical results were assigned the data qualifier "R".

4.6 Comparability

Comparability is a very important qualitative data indicator for analytical assessment and is a critical parameter when considering the combination of data sets from different analyses for the same chemicals of potential concern. The analytical methods used provided common analytical parameters, identical units of measure, and similar detection limits.

5.0 DATA SUMMARY AND CONCLUSIONS

Quarterly groundwater sampling activities at the CCAS were conducted in February, May, August, and November 1998 and included the collection of groundwater samples for analysis of VOCs. Sampling activities were conducted in accordance with the project work plan. Kemron Environmental Services (Marietta, Ohio) performed the analyses. Field QC samples included trip blanks, equipment rinsate blanks, ambient field blanks, and field duplicates. Analytical QC samples included method blanks, SCS/DCS samples, and MS/MSD samples. All samples for VOCs analyses were spiked with surrogate compounds.

Analytical results were validated based on a review of custody information, method blanks, laboratory single control samples and duplicate control samples (SCS/DCS), surrogate spikes, and matrix spike/matrix spike duplicates (MS/MSD). Where applicable, the analytical results were evaluated with respect to guidelines adapted from the most current editions of Test Methods for Evaluating Solid Waste-Physical/Chemical Methods, EPA/SW-846, 3rd Edition (1986) and Update III (1996) and the Air Force Center for Environmental Excellence (AFCEE) Quality Assurance Project Plan (QAPP), Version 3 (AFCEE, March 1998). EPA "ten times" and "five times" rules were used to discount both field- and laboratory-induced contaminants from being site-related. The "L" flag was applied to data that were determined not to be site-related based on EPA data evaluation guidance. The "K" data qualifier was applied to data in cases when professional judgment must be used to determine if the detect is site-related. Analytical results flagged with the "R" data qualifier have been rejected due to deficiencies in the ability of the laboratory to analyze the sample and meet established QC criteria.

The data quality objectives for the analytical data as discussed in this report were met, and the data can be used for the purpose stated in the Work Plan.

Summary of Analytical Test Results
Intermediate Monitoring Wells
Cape Canaveral Air Station
February 1998 Sampling

Sample ID Date Collected Lab Sample ID		C-HGRK-PRTMWI01 2/18/98 L9802372-11	C-HGRK-PRTMWI02 2/17/98 L9802372-05	C-HGRK-PRTMWI03 2/18/98 L9802372-12	C-HGRK-PRTMWI05 2/17/98 L9802372-06	C-HGRK-PRTMWI07 2/17/98 L9802372-03	C-HGRK-PRTMWI09 2/17/98 L9802372-01	C-HGRK-PRTMWI11 2/18/98 L9802372-13
Total Dissolved Solids (mg/L)	mg/L	NA	NA	180	52	52	NA	NA
1,1,1-Trichloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-Tetrachloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-Trichloroethane	ug/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,1-Dichloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-Dichloroethene	ug/L	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
1,2-Dichloroethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-Dichloropropane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Butanone	ug/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10
2-Hexanone	ug/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10
4-Methyl-2-pentanone	ug/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Acetone	ug/L	< 10	1 F/	< 10	3 F/	8.9 F/	4.2 F/	< 10
Benzene	ug/L	< 0.5	< 0.5	< 0.5	0.13 F/	0.14 F/	< 0.5	< 0.5
Bromodichloromethane	ug/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bromoform	ug/L	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
Bromomethane	ug/L	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1
Carbon disulfide	ug/L	< 5	< 5	< 5	0.11 F/	< 5	< 5	< 5
Carbon tetrachloride	ug/L	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1
Chlorobenzene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Chlorodibromomethane	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Chloroethane	ug/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chloroform	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Chloromethane	ug/L	< 1.3	0.18 F/	< 1.3	< 1.3	0.13 F/	< 1.3	< 1.3
cis-1,2-Dichloroethene	ug/L	0.9 F/	93	< 1.2	38	210 D/	48	3.5 /JI
cis-1,3-Dichloropropene	ug/L	< 0.5	< 0.5	0.73	< 0.5	< 0.5	< 0.5	< 0.5
Ethylbenzene	ug/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1
m-,p-Xylene	ug/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Methylene chloride	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
o-Xylene	ug/L	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1
Styrene	ug/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Tetrachloroethene	ug/L	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
Toluene	ug/L	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
trans-1,2-Dichloroethene	ug/L	0.44 F/	< 0.5	< 0.5	0.24 F/	0.13 F/	< 0.5	0.73 F/JI
trans-1,3-Dichloropropene	ug/L	< 0.5	< 0.5	0.34 F/	< 0.5	< 0.5	< 0.5	< 0.5
Trichloroethene	ug/L	< 1	< 1	0.32 F/	< 1	< 1	< 1	0.69 F/JI
Vinyl chloride	ug/L	< 1.1	52	< 1.1	25	66	60	0.9 F/JI

Summary of Analytical Test Results
Intermediate Monitoring Wells
Cape Canaveral Air Station
February 1998 Sampling

Sample ID Date Collected Lab Sample ID		C-HGRK-PRTMWI12 2/18/98 L9802372-07		C-HGRK-PRTMWI13 2/18/98 L9802372-14		C-HGRK-PRTMWI14 2/18/98 L9802372-08		C-HGRK-PRTMWI15 2/18/98 L9802372-15		C-HGRK-PRTMWI16 2/18/98 L9802372-09		C-HGRK-PRTMWI17 2/17/98 L9802372-04	
Total Dissolved Solids (mg/L)	mg/L	NA		NA		NA		NA		NA		NA	
1,1,1-Trichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1,2,2-Tetrachloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1,2-Trichloroethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
1,1-Dichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1-Dichloroethene	ug/L	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2	
1,2-Dichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,2-Dichloropropane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
2-Butanone	ug/L	< 10		< 10		10		< 10		31		120	D/
2-Hexanone	ug/L	< 10		< 10		< 10		< 10		< 10		< 10	
4-Methyl-2-pentanone	ug/L	< 10		< 10		< 10		< 10		< 10		< 10	
Acetone	ug/L	< 10		< 10		4.6	F/LVF	2	F/LVFJI	11	/LVF	15	
Benzene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		0.31	F/	0.44	F/
Bromodichloromethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
Bromoform	ug/L	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2	
Bromomethane	ug/L	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	
Carbon disulfide	ug/L	< 5		< 5		< 5		< 5		< 5		< 5	
Carbon tetrachloride	ug/L	< 2.1		< 2.1		< 2.1		< 2.1		< 2.1		< 2.1	
Chlorobenzene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chlorodibromomethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chloroethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
Chloroform	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chloromethane	ug/L	< 1.3		< 1.3		< 1.3		< 1.3		< 1.3		< 1.3	
cis-1,2-Dichloroethene	ug/L	38		16		250	D/	65	/JI	170	D/	65	
cis-1,3-Dichloropropene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Ethylbenzene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
m-,p-Xylene	ug/L	< 1		< 1		< 1		< 1		0.44	FX/	< 1	
Methylene chloride	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		0.12	F/
o-Xylene	ug/L	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	
Styrene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
Tetrachloroethene	ug/L	< 1.4		< 1.4		< 1.4		< 1.4		< 1.4		< 1.4	
Toluene	ug/L	< 1.2		< 1.2		< 1.2		< 1.2		0.66	F/	0.39	F/
trans-1,2-Dichloroethene	ug/L	< 0.5		1.8		2		4.5	/JI	1.8		1.9	
trans-1,3-Dichloropropene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		0.63		< 0.5	
Trichloroethene	ug/L	< 1		0.54	F/	< 1		0.49	F/JI	< 1		< 1	
Vinyl chloride	ug/L	8.4		2.5		210	D/	29	/JI	210	D/	370	D/

Summary of Analytical Test Results
Intermediate Monitoring Wells
Cape Canaveral Air Station
February 1998 Sampling

Sample ID Date Collected Lab Sample ID			C-HGRK-PRTMWI18 2/17/98 L9802372-02			C-HGRK-PRTMWI19 2/18/98 L9802372-16			C-HGRK-PRTMWI20 2/18/98 L9802372-10	
Total Dissolved Solids (mg/L)	mg/L		NA			NA			NA	
1,1,1-Trichloroethane	ug/L	<	0.5		<	0.5		<	0.5	
1,1,2,2-Tetrachloroethane	ug/L	<	0.5		<	0.5		<	0.5	
1,1,2-Trichloroethane	ug/L	<	1		<	1		<	1	
1,1-Dichloroethane	ug/L	<	0.5		<	0.5		<	0.5	
1,1-Dichloroethene	ug/L		0.75	F/		0.26	F/	<	1.2	
1,2-Dichloroethane	ug/L	<	0.5		<	0.5		<	0.5	
1,2-Dichloropropane	ug/L	<	0.5		<	0.5		<	0.5	
2-Butanone	ug/L		3.2	F/	<	10			50	
2-Hexanone	ug/L	<	10		<	10		<	10	
4-Methyl-2-pentanone	ug/L	<	10		<	10		<	10	
Acetone	ug/L		4.7	F/	<	10			28	/LVF
Benzene	ug/L		0.11	F/	<	0.5			1.7	
Bromodichloromethane	ug/L	<	1		<	1		<	1	
Bromoform	ug/L	<	1.2		<	1.2		<	1.2	
Bromomethane	ug/L	<	1.1		<	1.1		<	1.1	
Carbon disulfide	ug/L	<	5		<	5		<	5	
Carbon tetrachloride	ug/L	<	2.1		<	2.1		<	2.1	
Chlorobenzene	ug/L	<	0.5		<	0.5		<	0.5	
Chlorodibromomethane	ug/L	<	0.5		<	0.5		<	0.5	
Chloroethane	ug/L	<	1		<	1		<	1	
Chloroform	ug/L	<	0.5		<	0.5		<	0.5	
Chloromethane	ug/L	<	1.3		<	1.3		<	1.3	
cis-1,2-Dichloroethene	ug/L		470	D/		160	D/		98	
cis-1,3-Dichloropropene	ug/L	<	0.5		<	0.5		<	0.5	
Ethylbenzene	ug/L	<	1		<	1			0.56	F/
m-,p-Xylene	ug/L	<	1		<	1			0.86	FX/
Methylene chloride	ug/L	<	0.5		<	0.5		<	0.5	
o-Xylene	ug/L	<	1.1		<	1.1			0.27	F/
Styrene	ug/L	<	1		<	1		<	1	
Tetrachloroethene	ug/L	<	1.4		<	1.4		<	1.4	
Toluene	ug/L		0.19	F/	<	1.2			2.2	
trans-1,2-Dichloroethene	ug/L		13			2.5			2	
trans-1,3-Dichloropropene	ug/L	<	0.5		<	0.5		<	0.5	
Trichloroethene	ug/L	<	1		<	1		<	1	
Vinyl chloride	ug/L		490	D/		220	D/		100	D/

Summary of Analytical Test Results
Deep Monitoring Wells
Cape Canaveral Air Station
February 1998 Sampling

Sample ID / Date Collected / Lab Sample ID	C-HGRK-PRTMWD01 2/23/98 L9802427-08	C-HGRK-PRTMWD02 2/20/98 L9802427-02	C-HGRK-PRTMWD03 2/23/98 L9802427-09	C-HGRK-PRTMWD03-a 2/23/98 L9802427-10	C-HGRK-PRTMWD05 2/20/98 L9802427-03	C-HGRK-PRTMWD07 2/19/98 L9802372-22	C-HGRK-PRTMWD09 2/19/98 L9802372-20
Total Dissolved Solids (mg/L)	NA	NA	550	NA	530	490	NA
1,1,1-Trichloroethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
1,1,2,2-Tetrachloroethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
1,1,2-Trichloroethane	< 100	< 100	< 100	< 100	< 100	< 100	< 100
1,1-Dichloroethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
1,1-Dichloroethene	< 120	< 120	190 /JI	190	< 120	< 120	80 F/
1,2-Dichloroethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
1,2-Dichloropropane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2-Butanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
2-Hexanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
4-Methyl-2-pentanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Acetone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Benzene	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Bromodichloromethane	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Bromoform	< 120	< 120	< 120	< 120	< 120	< 120	< 120
Bromomethane	< 110	< 110	< 110	< 110	< 110	< 110	< 110
Carbon disulfide	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Carbon tetrachloride	< 210	< 210	< 210	< 210	< 210	< 210	< 210
Chlorobenzene	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Chlorodibromomethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Chloroethane	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Chloroform	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Chloromethane	< 130	< 130	< 130	< 130	< 130	< 130	< 130
cis-1,2-Dichloroethene	93000 D/	40000 D/	35000 D/JI	41000 D/	93000 D/	52000 D/	68000 D/
cis-1,3-Dichloropropene	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Ethylbenzene	< 100	< 100	< 100	< 100	< 100	< 100	< 100
m-,p-Xylene	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Methylene chloride	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Xylene	< 110	< 110	< 110	< 110	< 110	< 110	< 110
Styrene	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Tetrachloroethene	< 140	< 140	< 140	< 140	< 140	< 140	< 140
Toluene	< 120	< 120	< 120	< 120	< 120	< 120	< 120
trans-1,2-Dichloroethene	490	570 D/	1600 /JI	1600	930	190	770
trans-1,3-Dichloropropene	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Trichloroethene	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Vinyl chloride	58000 D/	20000 D/	5700 D/JI	7000 D/	54000 D/	45000 D/	62000 D/

Summary of Analytical Test Results
Deep Monitoring Wells
Cape Canaveral Air Station
February 1998 Sampling

Sample ID	C-HGRK-PRTMWD11	C-HGRK-PRTMWD12	C-HGRK-PRTMWD13	C-HGRK-PRTMWD13-a	C-HGRK-PRTMWD14	C-HGRK-PRTMWD15	C-HGRK-PRTMWD16
Date Collected	2/23/98	2/20/98	2/23/98	2/23/98	2/20/98	2/23/98	2/20/98
Lab Sample ID	L9802427-11	L9802427-04	L9802427-12	L9802427-13	L9802427-05	L9802427-14	L9802427-06
Total Dissolved Solids (mg/L)	NA	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
1,1,2,2-Tetrachloroethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
1,1,2-Trichloroethane	< 100	< 100	< 100	< 100	< 100	< 100	< 100
1,1-Dichloroethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
1,1-Dichloroethene	250 /JI	< 120	270 /JI	280 /JI	< 120	240	< 120
1,2-Dichloroethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
1,2-Dichloropropane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
2-Butanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
2-Hexanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
4-Methyl-2-pentanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Acetone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Benzene	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Bromodichloromethane	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Bromoform	< 120	< 120	< 120	< 120	< 120	< 120	< 120
Bromomethane	< 110	< 110	< 110	< 110	< 110	< 110	< 110
Carbon disulfide	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Carbon tetrachloride	< 210	< 210	< 210	< 210	< 210	< 210	< 210
Chlorobenzene	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Chlorodibromomethane	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Chloroethane	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Chloroform	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Chloromethane	< 130	< 130	< 130	< 130	< 130	< 130	< 130
cis-1,2-Dichloroethene	75000 D/JI	87000 D/	59000 D/JI	59000 D/JI	47000 D/	160000 D/	28000 D/
cis-1,3-Dichloropropene	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Ethylbenzene	< 100	< 100	< 100	< 100	< 100	< 100	< 100
m-,p-Xylene	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Methylene chloride	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Xylene	< 110	< 110	< 110	< 110	< 110	< 110	< 110
Styrene	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Tetrachloroethene	< 140	< 140	< 140	< 140	< 140	< 140	< 140
Toluene	< 120	< 120	< 120	< 120	< 120	< 120	< 120
trans-1,2-Dichloroethene	1700 /JI	190	1700 /JI	1800 /JI	670	1900	640
trans-1,3-Dichloropropene	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Trichloroethene	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Vinyl chloride	9800 D/JI	4800	29000 D/JI	27000 D/JI	38000 D/	34000 D/	63000 D/

Summary of Analytical Test Results
Deep Monitoring Wells
Cape Canaveral Air Station
February 1998 Sampling

Sample ID		C-HGRK-PRTMWD17			C-HGRK-PRTMWD18			C-HGRK-PRTMWD19			C-HGRK-PRTMWD19-a			C-HGRK-PRTMWD20	
Date Collected		2/20/98			2/19/98			2/23/98			2/23/98			2/23/98	
Lab Sample ID		L9802427-01			L9802372-21			L9802427-15			L9802427-16			L9802427-07	
Total Dissolved Solids (mg/L)		NA			NA			NA			NA			NA	
1,1,1-Trichloroethane	<	0.5		<	50		<	50		<	250		<	50	
1,1,2,2-Tetrachloroethane	<	0.5		<	50		<	50		<	250		<	50	
1,1,2-Trichloroethane	<	1		<	100		<	100		<	500		<	100	
1,1-Dichloroethane		13	/JI	<	50		<	50		<	250		<	50	
1,1-Dichloroethene		260	I/JI		140			260	/JI	<	600		<	120	
1,2-Dichloroethane	<	0.5		<	50		<	50		<	250		<	50	
1,2-Dichloropropane	<	0.5		<	50		<	50		<	250		<	50	
2-Butanone	<	10		<	1000		<	1000		<	5000		<	1000	
2-Hexanone	<	10		<	1000		<	1000		<	5000		<	1000	
4-Methyl-2-pentanone	<	10		<	1000		<	1000		<	5000		<	1000	
Acetone	<	10		<	1000		<	1000		<	5000		<	1000	
Benzene	<	0.5		<	50		<	50		<	250		<	50	
Bromodichloromethane	<	1		<	100		<	100		<	500		<	100	
Bromoform	<	1.2		<	120		<	120		<	600		<	120	
Bromomethane	<	1.1		<	110		<	110		<	550		<	110	
Carbon disulfide		5.4	/JI	<	500		<	500		<	2500		<	500	
Carbon tetrachloride	<	2.1		<	210		<	210		<	1100		<	210	
Chlorobenzene	<	0.5		<	50		<	50		<	250		<	50	
Chlorodibromomethane	<	0.5		<	50		<	50		<	250		<	50	
Chloroethane	<	1		<	100		<	100		<	500		<	100	
Chloroform	<	0.5		<	50		<	50		<	250		<	50	
Chloromethane	<	1.3		<	130		<	130		<	650		<	130	
cis-1,2-Dichloroethene		5000	D/JI		97000	D/		170000	D/JI		190000	D/JI		42000	D/
cis-1,3-Dichloropropene	<	0.5		<	50		<	50		<	250		<	50	
Ethylbenzene	<	1		<	100		<	100		<	500		<	100	
m-,p-Xylene	<	1		<	100		<	100		<	500		<	100	
Methylene chloride		0.5	/JI	<	50		<	50		<	250		<	50	
o-Xylene	<	1.1		<	110		<	110		<	550		<	110	
Styrene	<	1		<	100		<	100		<	500		<	100	
Tetrachloroethene	<	1.4		<	140		<	140		<	700		<	140	
Toluene		2.5	/JI	<	120		<	120		<	600		<	120	
trans-1,2-Dichloroethene		740	D/JI		1500			2200	/JI		1900	/JI		950	
trans-1,3-Dichloropropene	<	0.5		<	50		<	50		<	250		<	50	
Trichloroethene		5.8	/JI	<	100		<	100		<	500		<	100	
Vinyl chloride		1600	D/JI		37000	D/		15000	D/JIA		35000	/JI		43000	D/

Summary of Analytical Test Results
QA/QC Samples
Cape Canaveral Air Station
February 1998 Sampling

Sample ID Date Collected Lab Sample ID	C-HGRK-PRTAMBK01 2/18/98 L9802372-18	C-HGRK-PRTAMBK02 2/23/98 L9802427-18	C-HGRK-PRTEQBK01 2/18/98 L9802372-17	C-HGRK-PRTEQBK02 2/23/98 L9802427-17	C-HGRK-PRTTPBK01 2/18/98 L9802372-19	C-HGRK-PRTTPBK02 2/23/98 L9802427-19
1,1,1-Trichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2,2-Tetrachloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1,2-Trichloroethane	< 1	< 1	< 1	< 1	< 1	< 1
1,1-Dichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,1-Dichloroethene	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
1,2-Dichloroethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1,2-Dichloropropane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
2-Butanone	< 10	< 10	< 10	< 10	< 10	< 10
2-Hexanone	< 10	< 10	< 10	< 10	< 10	< 10
4-Methyl-2-pentanone	< 10	< 10	< 10	< 10	< 10	< 10
Acetone	21	< 10	19	< 10	< 10	< 10
Benzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Bromodichloromethane	< 1	< 1	< 1	< 1	< 1	< 1
Bromoform	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
Bromomethane	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1
Carbon disulfide	< 5	< 5	< 5	< 5	< 5	< 5
Carbon tetrachloride	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1
Chlorobenzene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Chlorodibromomethane	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Chloroethane	< 1	< 1	< 1	< 1	< 1	< 1
Chloroform	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Chloromethane	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3
cis-1,2-Dichloroethene	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
cis-1,3-Dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Ethylbenzene	< 1	< 1	< 1	< 1	< 1	< 1
m-,p-Xylene	< 1	< 1	< 1	< 1	< 1	< 1
Methylene chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
o-Xylene	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1
Styrene	< 1	< 1	< 1	< 1	< 1	< 1
Tetrachloroethene	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
Toluene	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
trans-1,2-Dichloroethene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
trans-1,3-Dichloropropene	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Trichloroethene	< 1	< 1	< 1	< 1	< 1	< 1
Vinyl chloride	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1	< 1.1

Summary of Analytical Results
Deep Monitoring Wells
Cape Canaveral Air Station
May 1998 Sampling

Sample ID Date Collected Lab Sample ID	C-HGRK-PRTMWD01 5/20/98 L9805421-01	C-HGRK-PRTMWD01-a 5/20/98 L9805421-02	C-HGRK-PRTMWD02 5/20/98 L9805421-03	C-HGRK-PRTMWD03 5/20/98 L9805421-04	C-HGRK-PRTMWD05 5/20/98 L9805421-05	C-HGRK-PRTMWD07 5/20/98 L9805421-06
1,1,1-Trichloroethane	< 500	< 500	< 500	< 500	< 500	< 500
1,1,2,2-Tetrachloroethane	< 500	< 500	< 500	< 500	< 500	< 500
1,1,2-Trichloroethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
1,1-Dichloroethane	< 500	< 500	< 500	< 500	< 500	< 500
1,1-Dichloroethene	< 1200	< 1200	< 1200	< 1200	< 1200	< 1200
1,2-Dichloroethane	< 500	< 500	< 500	< 500	< 500	< 500
1,2-Dichloropropane	< 500	< 500	< 500	< 500	< 500	< 500
Bromodichloromethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Carbon tetrachloride	< 2100	< 2100	< 2100	< 2100	< 2100	< 2100
Chlorobenzene	< 500	< 500	< 500	< 500	< 500	< 500
Chloroethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Chloroform	< 500	< 500	< 500	< 500	< 500	< 500
Chloromethane	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/
cis-1,2-Dichloroethene	57000	73000	45000	100000	45000	17000
cis-1,3-Dichloropropene	< 500	< 500	< 500	< 500	< 500	< 500
Dibromochloromethane	< 500	< 500	< 500	< 500	< 500	< 500
Methylene chloride	< 500	< 500	< 500	< 500	< 500	< 500
Tetrachloroethene	< 1400	< 1400	< 1400	< 1400	< 1400	< 1400
trans-1,2-Dichloroethene	800 F/	1100	860 F/	1600	790	< 500
trans-1,3-Dichloropropene	< 500	< 500	< 500	< 500	< 500	< 500
Trichloroethene	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Vinyl chloride	33000	43000	47000	42000	55000	35000

Summary of Analytical Results
Deep Monitoring Wells
Cape Canaveral Air Station
May 1998 Sampling

Sample ID	C-HGRK-PRTMWD09	C-HGRK-PRTMWD11	C-HGRK-PRTMWD11-a	C-HGRK-PRTMWD12	C-HGRK-PRTMWD13	C-HGRK-PRTMWD14
Date Collected	5/20/98	5/21/98	5/21/98	5/20/98	5/21/98	5/20/98
Lab Sample ID	L9805421-07	L9805421-08	L9805421-09	L9805421-10	L9805421-11	L9805421-12
1,1,1-Trichloroethane	< 500	< 500	< 500	< 500	< 500	< 500
1,1,2,2-Tetrachloroethane	< 500	< 500	< 500	< 500	< 500	< 500
1,1,2-Trichloroethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
1,1-Dichloroethane	< 500	< 500	< 500	< 500	< 500	< 500
1,1-Dichloroethene	< 1200	< 1200	< 1200	< 1200	270 F/	< 1200
1,2-Dichloroethane	< 500	< 500	300 F/	< 500	< 500	< 500
1,2-Dichloropropane	< 500	< 500	< 500	< 500	< 500	< 500
Bromodichloromethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Carbon tetrachloride	< 2100	< 2100	< 2100	< 2100	< 2100	< 2100
Chlorobenzene	< 500	< 500	< 500	< 500	< 500	< 500
Chloroethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Chloroform	< 500	< 500	< 500	< 500	< 500	< 500
Chloromethane	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/
cis-1,2-Dichloroethene	47000	140000	150000 M/	48000	150000 M/	51000
cis-1,3-Dichloropropene	< 500	< 500	< 500	< 500	< 500	< 500
Dibromochloromethane	< 500	< 500	< 500	< 500	< 500	< 500
Methylene chloride	< 500	< 500	< 500	< 500	< 500	< 500
Tetrachloroethene	< 1400	< 1400	< 1400	< 1400	< 1400	< 1400
trans-1,2-Dichloroethene	760 F/	1900	2000	< 500	2200	990 F/
trans-1,3-Dichloropropene	< 500	< 500	< 500	< 500	< 500	< 500
Trichloroethene	< 1000	< 1000	< 1000 /m	< 1000	< 1000	< 1000
Vinyl chloride	42000	31000	28000	33000	26000	40000

Summary of Analytical Results
Deep Monitoring Wells
Cape Canaveral Air Station
May 1998 Sampling

Sample ID	C-HGRK-PRTMWD15	C-HGRK-PRTMWD15-a	C-HGRK-PRTMWD16	C-HGRK-PRTMWD17	C-HGRK-PRTMWD18	C-HGRK-PRTMWD19	C-HGRK-PRTMWD20
Date Collected	5/21/98	5/21/98	5/20/98	5/20/98	5/20/98	5/21/98	5/20/98
Lab Sample ID	L9805421-13	L9805421-14	L9805421-15	L9805421-16	L9805421-17	L9805421-18	L9805421-19
1,1,1-Trichloroethane	< 500	< 500	< 500	< 500	< 500	< 500	< 500
1,1,2,2-Tetrachloroethane	< 500	< 500	< 500	< 500	< 500	< 500	< 500
1,1,2-Trichloroethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
1,1-Dichloroethane	< 500	< 500	< 500	< 500	< 500	1000	< 1000
1,1-Dichloroethene	300 F/	300 F/	< 1200	< 1200	< 1200	220 F/	< 500
1,2-Dichloroethane	< 500	< 500	< 500	< 500	< 500	< 1200	< 1200
1,2-Dichloropropane	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Bromodichloromethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Carbon tetrachloride	< 2100	< 2100	< 2100	< 2100	< 2100	< 2100	< 2100
Chlorobenzene	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Chloroethane	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Chloroform	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Chloromethane	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/	< 1300 M/
cis-1,2-Dichloroethene	160000 M/	150000 M/	69000	98000	76000	150000 M/	110000
cis-1,3-Dichloropropene	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Dibromochloromethane	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Methylene chloride	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Tetrachloroethene	< 1400	< 1400	< 1400	< 1400	< 1400	< 1400	< 1400
trans-1,2-Dichloroethene	2300	2300	1300	2000	1400	2500	1900
trans-1,3-Dichloropropene	< 500	< 500	< 500	< 500	< 500	< 500	< 500
Trichloroethene	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Vinyl chloride	33000	34000	67000	53000	49000	22000	39000

Summary of Analytical Results
QA/QC Samples
Cape Canaveral Air Station
May 1998 Sampling

Sample ID		C-HGRK-PRTAMBK03			C-HGRK-PRTAMBK04			C-HGRK-PRTEQBK03			C-HGRK-PRTEQBK04			C-HGRK-PRTTPBK03	
Date Collected		5/20/98			5/21/98			5/20/98			5/21/98			5/20/98	
Lab Sample ID		L9805421-22			L9805421-23			L9805421-20			L9805421-21			L9805421-24	
1,1,1-Trichloroethane	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
1,1,2,2-Tetrachloroethane	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
1,1,2-Trichloroethane	<	1		<	1		<	1		<	1		<	1	
1,1-Dichloroethane	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
1,1-Dichloroethene	<	1.2	M/	<	1.2	M/	<	1.2	M/	<	1.2	M/	<	1.2	M/
1,2-Dichloroethane	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
1,2-Dichloropropane	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
Bromodichloromethane	<	1		<	1		<	1		<	1		<	1	
Carbon tetrachloride	<	2.1		<	2.1		<	2.1		<	2.1		<	2.1	
Chlorobenzene	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
Chloroethane	<	1		<	1		<	1		<	1		<	1	
Chloroform	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
Chloromethane	<	1.3		<	1.3		<	1.3		<	1.3		<	1.3	
cis-1,2-Dichloroethene	<	1.2	M/	<	1.2	M/	<	1.2	M/	<	1.2	M/	<	1.2	M/
cis-1,3-Dichloropropene	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
Dibromochloromethane	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
Methylene chloride	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
Tetrachloroethene	<	1.4		<	1.4		<	1.4		<	1.4		<	1.4	
trans-1,2-Dichloroethene	<	0.5	M/	<	0.5	M/	<	0.5	M/	<	0.5	M/	<	0.5	M/
trans-1,3-Dichloropropene	<	0.5		<	0.5		<	0.5		<	0.5		<	0.5	
Trichloroethene	<	1	M/	<	1	M/	<	1	M/	<	1	M/	<	1	M/
Vinyl chloride	<	1.1	M/	<	1.1	M/	<	1.1	M/	<	1.1	M/	<	1.1	M/

Summary of Analytical Results
Intermediate Monitoring Wells
Cape Canaveral Air Station
August 1998 Sampling

Sample ID / Lab Sample ID / Date Collected		C-HGRK-PRTMWI01 L9808499-13 8/26/98		C-HGRK-PRTMWI02 L9808499-07 8/26/98		C-HGRK-PRTMWI03 L9808499-14 8/26/98		C-HGRK-PRTMWI05 L9808499-08 8/26/98		C-HGRK-PRTMWI07 L9808499-05 8/26/98		C-HGRK-PRTMWI09 L9808499-01 8/25/98		C-HGRK-PRTMWI11 L9808499-15 8/26/98	
1,1,1-Trichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1,2,2-Tetrachloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1,2-Trichloroethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
1,1-Dichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1-Dichloroethene	ug/L	< 1.2		< 1.2		< 1.2		< 1.2	/m	< 1.2		< 1.2		< 1.2	
1,2-Dichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,2-Dichloropropane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
2-Butanone	ug/L	< 10		< 10		< 10		< 10		< 10		< 10		< 10	
2-Hexanone	ug/L	< 10		< 10		< 10		< 10		< 10		< 10		< 10	
4-Methyl-2-pentanone	ug/L	< 10		< 10		< 10		< 10		< 10		< 10		< 10	
Acetone	ug/L	< 10	/Rc	2.6	F/Jc	< 10	/Rc	2.4	F/Jcm	3	F/Jc	2.3	F/Jc	< 10	/Rc
Benzene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Bromodichloromethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Bromoform	ug/L	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2	
Bromomethane	ug/L	< 1.1		< 1.1		< 1.1		< 1.1	/m	< 1.1		< 1.1		< 1.1	
Carbon disulfide	ug/L	< 5		< 5		< 5		< 5	/m	< 5		< 5		< 5	
Carbon tetrachloride	ug/L	< 2.1		< 2.1		< 2.1		< 2.1		< 2.1		< 2.1		< 2.1	
Chlorobenzene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chloroethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Chloroform	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chloromethane	ug/L	< 1.3		< 1.3		< 1.3		< 1.3	/m	< 1.3		< 1.3		< 1.3	
cis-1,2-Dichloroethene	ug/L	1.2	F/	2.6		1.4		0.73	F/	3		2.2		9.5	M/m
cis-1,3-Dichloropropene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Dibromochloromethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Ethylbenzene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
m-,p-Xylene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Methylene chloride	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
o-Xylene	ug/L	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	
Styrene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Tetrachloroethene	ug/L	< 1.4		< 1.4		< 1.4		< 1.4		< 1.4		< 1.4		< 1.4	
Toluene	ug/L	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2	
trans-1,2-Dichloroethene	ug/L	0.4	F/	< 0.5		0.45	F/	< 0.5		< 0.5		< 0.5		0.42	F/
trans-1,3-Dichloropropene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Trichloroethene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Vinyl chloride	ug/L	< 1.1		0.57	F/	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	

Summary of Analytical Results
Intermediate Monitoring Wells
Cape Canaveral Air Station
August 1998 Sampling

Sample ID	C-HGRK-PRTMWI12		C-HGRK-PRTMWI13		C-HGRK-PRTMWI14		C-HGRK-PRTMWI15		C-HGRK-PRTMWI16		C-HGRK-PRTMWI17		C-HGRK-PRTMWI18	
Lab Sample ID	L9808499-09		L9808499-16		L9808499-10		L9808499-17		L9808499-11		L9808499-06		L9808499-02	
Date Collected	8/26/98		8/26/98		8/26/98		8/26/98		8/26/98		8/26/98		8/25/98	
1,1,1-Trichloroethane	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1,2,2-Tetrachloroethane	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1,2-Trichloroethane	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
1,1-Dichloroethane	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1-Dichloroethene	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2	
1,2-Dichloroethane	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,2-Dichloropropane	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
2-Butanone	< 10		< 10		< 10		< 10		< 10		1.4	F/	< 10	
2-Hexanone	< 10		< 10		< 10		< 10		< 10		< 10		< 10	
4-Methyl-2-pentanone	< 10		< 10		< 10		< 10		< 10		< 10		< 10	
Acetone	< 10	/Rc	2.5	F/Jc	2.3	F/Jc	< 10	/Rc	2.28	F/Jc	4	F/Jc	4.6	F/Jc
Benzene	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		0.42	F/	0.31	F/
Bromodichloromethane	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Bromoform	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2	
Bromomethane	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	
Carbon disulfide	< 5		< 5		< 5		< 5		< 5		< 5		< 5	
Carbon tetrachloride	< 2.1		< 2.1		< 2.1		< 2.1		< 2.1		< 2.1		< 2.1	
Chlorobenzene	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chloroethane	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Chloroform	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chloromethane	< 1.3		< 1.3		< 1.3		< 1.3		< 1.3		< 1.3		< 1.3	
cis-1,2-Dichloroethene	1.8		6.1	M/	2.6		7.6	M/	67.5		1.6		1.6	
cis-1,3-Dichloropropene	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Dibromochloromethane	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Ethylbenzene	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
m-,p-Xylene	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Methylene chloride	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
o-Xylene	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	
Styrene	< 1		< 1		< 1		< 1		< 1		< 1		< 1	
Tetrachloroethene	< 1.4		< 1.4		< 1.4		< 1.4		< 1.4		< 1.4		< 1.4	
Toluene	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		0.27	F/	0.5	F/
trans-1,2-Dichloroethene	< 0.5		1.4		< 0.5		1.8		4.95		< 0.5		< 0.5	
trans-1,3-Dichloropropene	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Trichloroethene	< 1		0.51	F/	< 1		0.39	F/	< 1		< 1		< 1	
Vinyl chloride	< 1.1		1.5		5.3		1.6		47.9		5.5		3.4	

Summary of Analytical Results
Intermediate Monitoring Wells
Cape Canaveral Air Station
August 1998 Sampling

Sample ID		C-HGRK-PRTMWI19			C-HGRK-PRTMWI20	
Lab Sample ID		L9808499-18			L9808499-12	
Date Collected		8/26/98			8/26/98	
1,1,1-Trichloroethane	<	0.5		<	0.5	
1,1,2,2-Tetrachloroethane	<	0.5		<	0.5	
1,1,2-Trichloroethane	<	1		<	1	
1,1-Dichloroethane	<	0.5		<	0.5	
1,1-Dichloroethene	<	1.2		<	1.2	
1,2-Dichloroethane	<	0.5		<	0.5	
1,2-Dichloropropane	<	0.5		<	0.5	
2-Butanone	<	10		<	10	
2-Hexanone	<	10		<	10	
4-Methyl-2-pentanone	<	10		<	10	
Acetone		2.3	F/Jc	<	10	/Rc
Benzene	<	0.5			0.49	F/
Bromodichloromethane	<	1		<	1	
Bromoform	<	1.2		<	1.2	
Bromomethane	<	1.1		<	1.1	
Carbon disulfide	<	5		<	5	
Carbon tetrachloride	<	2.1		<	2.1	
Chlorobenzene	<	0.5		<	0.5	
Chloroethane	<	1		<	1	
Chloroform	<	0.5		<	0.5	
Chloromethane	<	1.3		<	1.3	
cis-1,2-Dichloroethene		6.2	M/		0.64	F/
cis-1,3-Dichloropropene	<	0.5		<	0.5	
Dibromochloromethane	<	0.5		<	0.5	
Ethylbenzene	<	1		<	1	
m-,p-Xylene	<	1		<	1	
Methylene chloride	<	0.5		<	0.5	
o-Xylene	<	1.1		<	1.1	
Styrene	<	1		<	1	
Tetrachloroethene	<	1.4		<	1.4	
Toluene	<	1.2			0.64	F/
trans-1,2-Dichloroethene		1.3		<	0.5	
trans-1,3-Dichloropropene	<	0.5		<	0.5	
Trichloroethene	<	1		<	1	
Vinyl chloride		4.9			1.1	F/

Summary of Analytical Results
Deep Monitoring Wells
Cape Canaveral Air Station
August 1998 Sampling

Sample ID		C-HGRK-PRTMWD01		C-HGRK-PRTMWD02		C-HGRK-PRTMWD03		C-HGRK-PRTMWD03-a		C-HGRK-PRTMWD05		C-HGRK-PRTMWD07		C-HGRK-PRTMWD09	
Lab Sample ID		L9808499-30		L9808499-23		L9808499-31		L9808499-32		L9808499-24		L9808499-21		L9808499-19	
Date Collected		8/27/98		8/26/98		8/27/98		8/27/98		8/26/98		8/26/98		8/26/98	
1,1,1-Trichloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
1,1,2,2-Tetrachloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
1,1,2-Trichloroethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
1,1-Dichloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
1,1-Dichloroethene	ug/L	173		27	F/	231		240		50	F/	< 120		33	F/
1,2-Dichloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
1,2-Dichloropropane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
2-Butanone	ug/L	< 1000		< 1000		< 1000		< 1000		< 1000		< 1000		< 1000	
2-Hexanone	ug/L	< 1000		< 1000		< 1000		< 1000		< 1000		< 1000		< 1000	
4-Methyl-2-pentanone	ug/L	< 1000		< 1000		< 1000		< 1000		< 1000		< 1000		< 1000	
Acetone	ug/L	< 1000	/Rc	< 1000	/Rc	< 1000	/Rc	< 1000	/Rc	< 1000	/Rc	< 1000	/Rc	59	F/Jc
Benzene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Bromodichloromethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
Bromoform	ug/L	< 120	R/	< 120		< 120	R/	< 120	R/	< 120		< 120		< 120	
Bromomethane	ug/L	< 110		< 110		< 110		< 110		< 110		< 110		< 110	
Carbon disulfide	ug/L	< 500		< 500		< 500		< 500		< 500		< 500		< 500	
Carbon tetrachloride	ug/L	< 210		< 210		< 210		< 210		< 210		< 210		< 210	
Chlorobenzene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Chloroethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
Chloroform	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Chloromethane	ug/L	< 130		< 130		< 130		< 130		< 130		< 130		< 130	
cis-1,2-Dichloroethene	ug/L	89900		41000	M/	121000		120000		39000	M/	15000	M/	50000	M/
cis-1,3-Dichloropropene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Dibromochloromethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Ethylbenzene	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
m-,p-Xylene	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
Methylene chloride	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
o-Xylene	ug/L	< 110		< 110		< 110		< 110		< 110		< 110		< 110	
Styrene	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
Tetrachloroethene	ug/L	< 140		< 140		< 140		< 140		< 140		< 140		< 140	
Toluene	ug/L	< 120		< 120		< 120		< 120		< 120		< 120		< 120	
trans-1,2-Dichloroethene	ug/L	1470		790		1750		1800		750		220		770	
trans-1,3-Dichloropropene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Trichloroethene	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
Vinyl chloride	ug/L	70000		91000		55600		60000		82000		68000		71000	

Summary of Analytical Results
Deep Monitoring Wells
Cape Canaveral Air Station
August 1998 Sampling

Sample ID	C-HGRK-PRTMWD11	C-HGRK-PRTMWD12	C-HGRK-PRTMWD13	C-HGRK-PRTMWD13-a	C-HGRK-PRTMWD14	C-HGRK-PRTMWD15
Lab Sample ID	L9808499-33	L9808499-25	L9808499-34	L9808499-35	L9808499-26	L9808499-36
Date Collected	8/27/98	8/27/98	8/27/98	8/27/98	8/27/98	8/27/98
1,1,1-Trichloroethane	< 50	< 50	< 50	< 50	< 50	< 50
1,1,2,2-Tetrachloroethane	< 50	< 50	< 50	< 50	< 50	< 50
1,1,2-Trichloroethane	< 100	< 100	< 100	< 100	< 100	< 100
1,1-Dichloroethane	< 50	< 50	< 50	< 50	< 50	< 50
1,1-Dichloroethene	316	< 120	318	303	38 F/	193
1,2-Dichloroethane	< 50	< 50	< 50	< 50	< 50	< 50
1,2-Dichloropropane	< 50	< 50	< 50	< 50	< 50	< 50
2-Butanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
2-Hexanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
4-Methyl-2-pentanone	< 1000	< 1000	< 1000	< 1000	< 1000	< 1000
Acetone	< 1000 /Rc	< 1000 /Rc	< 1000 /Rc	< 1000 /Rc	< 1000 /Rc	< 1000 /Rc
Benzene	< 50	< 50	< 50	< 50	< 50	< 50
Bromodichloromethane	< 100	< 100	< 100	< 100	< 100	< 100
Bromoform	< 120 R/	< 120	< 120 R/	< 120 R/	< 120	< 120 R/
Bromomethane	< 110	< 110	< 110	< 110	< 110	< 110
Carbon disulfide	< 500	< 500	< 500	< 500	< 500	< 500
Carbon tetrachloride	< 210	< 210	< 210	< 210	< 210	< 210
Chlorobenzene	< 50	< 50	< 50	< 50	< 50	< 50
Chloroethane	< 100	< 100	< 100	< 100	< 100	< 100
Chloroform	< 50	< 50	< 50	< 50	< 50	< 50
Chloromethane	< 130 R/	< 130	< 130 R/	< 130 R/	< 130	< 130 R/
cis-1,2-Dichloroethene	147000	23000 M/	151000	145000	33000 M/	96800
cis-1,3-Dichloropropene	< 50	< 50	< 50	< 50	< 50	< 50
Dibromochloromethane	< 50	< 50	< 50	< 50	< 50	< 50
Ethylbenzene	< 100	< 100	< 100	< 100	< 100	< 100
m-,p-Xylene	< 100	< 100	< 100	< 100	< 100	21 F/
Methylene chloride	< 50	< 50	< 50	< 50	< 50	< 50
o-Xylene	< 110	< 110	< 110	< 110	< 110	< 110
Styrene	< 100	< 100	< 100	< 100	< 100	< 100
Tetrachloroethene	< 140	< 140	< 140	< 140	< 140	< 140
Toluene	< 120	< 120	< 120	< 120	< 120	< 120
trans-1,2-Dichloroethene	1790	200	1970	1870	800	1440
trans-1,3-Dichloropropene	< 50	< 50	< 50	< 50	< 50	< 50
Trichloroethene	< 100	< 100	< 100	< 100	< 100	< 100
Vinyl chloride	30500	68000	25100	23600	64000	34700

Summary of Analytical Results
Deep Monitoring Wells
Cape Canaveral Air Station
August 1998 Sampling

Sample ID	C-HGRK-PRTMWD16		C-HGRK-PRTMWD17		C-HGRK-PRTMWD18		C-HGRK-PRTMWD19		C-HGRK-PRTMWD19-a		C-HGRK-PRTMWD20	
Lab Sample ID	L9808499-28		L9808499-22		L9808499-20		L9808499-38		L9808499-39		L9808499-29	
Date Collected	8/27/98		8/26/98		8/26/98		8/27/98		8/27/98		8/27/98	
1,1,1-Trichloroethane	< 50		< 50		< 50		< 50		< 50		< 50	
1,1,2,2-Tetrachloroethane	< 50		< 50		< 50		< 50		< 50		< 50	
1,1,2-Trichloroethane	< 100		< 100		< 100		< 100		< 100		< 100	
1,1-Dichloroethane	< 50		< 50		< 50		< 50		< 50		< 50	
1,1-Dichloroethene	< 120		39	F/	< 120		280		321		< 120	
1,2-Dichloroethane	< 50		< 50		< 50		< 50		< 50		< 50	
1,2-Dichloropropane	< 50		< 50		< 50		< 50		< 50		< 50	
2-Butanone	< 1000		< 1000		< 1000		< 1000		< 1000		< 1000	
2-Hexanone	< 1000		< 1000		< 1000		< 1000		< 1000		< 1000	
4-Methyl-2-pentanone	< 1000		< 1000		< 1000		< 1000		< 1000		< 1000	
Acetone	< 1000	/Rc	< 1000	/Rc	< 1000	/Rc	< 1000	/Rc	< 1000	/Rc	< 1000	/Rc
Benzene	< 50		< 50		< 50		< 50		< 50		< 50	
Bromodichloromethane	< 100		< 100		< 100		< 100		< 100		< 100	
Bromoform	< 120	R/	< 120		< 120		< 120	R/	< 120	R/	< 120	R/
Bromomethane	< 110		< 110		< 110		< 110		< 110		< 110	
Carbon disulfide	< 500		< 500		< 500		< 500		< 500		< 500	
Carbon tetrachloride	< 210		< 210		< 210		< 210		< 210		< 210	
Chlorobenzene	< 50		< 50		< 50		< 50		< 50		< 50	
Chloroethane	< 100		< 100		< 100		< 100		< 100		< 100	
Chloroform	< 50		< 50		< 50		< 50		< 50		< 50	
Chloromethane	< 130		< 130		< 130		< 130	R/	< 130	R/	< 130	
cis-1,2-Dichloroethene	11800	M/	40000	M/	17000	M/	145000		146000	/M	14000	M/
cis-1,3-Dichloropropene	< 50		< 50		< 50		< 50		< 50		< 50	
Dibromochloromethane	< 50		< 50		< 50		< 50		< 50		< 50	
Ethylbenzene	< 100		< 100		< 100		< 100		< 100		< 100	
m-,p-Xylene	< 100		< 100		< 100		< 100		< 100		< 100	
Methylene chloride	< 50		< 50		< 50		< 50		< 50		< 50	
o-Xylene	< 110		< 110		< 110		< 110		< 110		< 110	
Styrene	< 100		< 100		< 100		< 100		< 100		< 100	
Tetrachloroethene	< 140		< 140		< 140		< 140		< 140		< 140	
Toluene	< 120		< 120		< 120		< 120		< 120		< 120	
trans-1,2-Dichloroethene	630		1300		990		2260		2440		790	
trans-1,3-Dichloropropene	< 50		< 50		< 50		< 50		< 50		< 50	
Trichloroethene	< 100		< 100		< 100		< 100		< 100		< 100	
Vinyl chloride	98600		120000		110000		33400		24600		100000	

Summary of Analytical Test Results
QA/QC Samples
Cape Canaveral Air Station
August 1998 Sampling

Sample ID		C-HGRK-PRTAMBK07		C-HGRK-PRTAMBK08		C-HGRK-PRTEQBK07		C-HGRK-PRTEQBK07		C-HGRK-PRTTPBK05		C-HGRK-PRTTPBK06	
Lab Sample ID		L9808499-03		L9808499-27		L9808499-04		L9808499-37		L9808499-40		L9808499-41	
Date Collected		8/26/98		8/27/98		8/26/98		8/27/98		8/27/98		8/27/98	
1,1,1-Trichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1,2,2-Tetrachloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1,2-Trichloroethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
1,1-Dichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,1-Dichloroethene	ug/L	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2	
1,2-Dichloroethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
1,2-Dichloropropane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
2-Butanone	ug/L	< 10		< 10		< 10		1.35	F/	< 10		< 10	
2-Hexanone	ug/L	< 10		< 10		< 10		< 10		< 10		< 10	
4-Methyl-2-pentanone	ug/L	< 10		< 10		< 10		< 10		< 10		< 10	
Acetone	ug/L	3.4	F/Jc	7.5	F/Jc	3.7	F/Jc	24.8	/Jc	< 10	/Rc	< 10	/Rc
Benzene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Bromodichloromethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
Bromoform	ug/L	< 1.2		< 1.2	R/	< 1.2		< 1.2		< 1.2		< 1.2	R/
Bromomethane	ug/L	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	
Carbon disulfide	ug/L	< 5		< 5		< 5		< 5		< 5		< 5	
Carbon tetrachloride	ug/L	< 2.1		< 2.1		< 2.1		< 2.1		< 2.1		< 2.1	
Chlorobenzene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chloroethane	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
Chloroform	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Chloromethane	ug/L	< 1.3		< 1.3		< 1.3		< 1.3		< 1.3		< 1.3	R/
cis-1,2-Dichloroethene	ug/L	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		0.47	F/
cis-1,3-Dichloropropene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Dibromochloromethane	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Ethylbenzene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
m-,p-Xylene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
Methylene chloride	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
o-Xylene	ug/L	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	
Styrene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
Tetrachloroethene	ug/L	< 1.4		< 1.4		< 1.4		< 1.4		< 1.4		< 1.4	
Toluene	ug/L	< 1.2		< 1.2		< 1.2		< 1.2		< 1.2		< 1.2	
trans-1,2-Dichloroethene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
trans-1,3-Dichloropropene	ug/L	< 0.5		< 0.5		< 0.5		< 0.5		< 0.5		< 0.5	
Trichloroethene	ug/L	< 1		< 1		< 1		< 1		< 1		< 1	
Vinyl chloride	ug/L	< 1.1		< 1.1		< 1.1		< 1.1		< 1.1		< 1.1	

Summary of Analytical Test Results
Deep Monitoring Wells
Cape Canaveral Air Station
November 1998 Sampling

Sample ID		C-HGRK-PRTMWD01		C-HGRK-PRTMWD02		C-HGRK-PRTMWD03		C-HGRK-PRTMWD03-a		C-HGRK-PRTMWD05		C-HGRK-PRTMWD07		C-HGRK-PRTMWD09	
Date Collected		11/18/98		11/18/98		11/18/98		11/18/98		11/18/98		11/18/98		11/18/98	
Lab Sample ID		L9811380-14		L9811380-05		L9811380-15		L9811380-16		L9811380-06		L9811380-04		L9811380-02	
Bromodichloromethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
Carbon tetrachloride	ug/L	< 210		< 210		< 210		< 210		< 210		< 210		< 210	
Chlorobenzene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Chloroethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
Chloroform	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Chloromethane	ug/L	< 130		< 130		< 130		< 130		< 130		< 130		< 130	
Dibromochloromethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
1,1-Dichloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
1,2-Dichloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
1,1-Dichloroethene	ug/L	142		110		212		213		105		< 120		56.8	F/
cis-1,2-Dichloroethene	ug/L	69800	/KFT	49100	/KFT	103000	/KFT	105000	/KFT	47400	/KFT	9890	/KFVT	31300	/KFT
trans-1,2-Dichloroethene	ug/L	1160		1160		1580		1620		1080		261		715	
1,2-Dichloropropane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
cis-1,3-Dichloropropene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
trans-1,3-Dichloropropene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Methylene chloride	ug/L	< 50		32.9	F/LT	< 50		< 50		< 50		< 50		< 50	
1,1,2,2-Tetrachloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
Tetrachloroethene	ug/L	< 140		< 140		< 140		< 140		< 140		< 140		< 140	
Trichloroethene	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
1,1,1-Trichloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50		< 50	
1,1,2-Trichloroethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100		< 100	
Vinyl chloride	ug/L	70900	/KT	71400	/KT	67400	/KT	70900	/KT	69300	/KT	43800	/KT	58900	/KT

Summary of Analytical Test Results
Deep Monitoring Wells
Cape Canaveral Air Station
November 1998 Sampling

Sample ID / Date Collected / Lab Sample ID		C-HGRK-PRTMWD11 11/18/98 L9811380-17			C-HGRK-PRTMWD12 11/18/98 L9811380-09			C-HGRK-PRTMWD13 11/19/98 L9811380-20			C-HGRK-PRTMWD13-a 11/19/98 L9811380-21			C-HGRK-PRTMWD14 11/18/98 L9811380-11			C-HGRK-PRTMWD15 11/19/98 L9811380-22		
Bromodichloromethane	ug/L	<	100		<	1000		<	100		<	100		<	100		<	100	
Carbon tetrachloride	ug/L	<	210		<	2100		<	210		<	210		<	210		<	210	
Chlorobenzene	ug/L	<	50		<	500		<	50		<	50		<	50		<	50	
Chloroethane	ug/L	<	100		<	1000		<	100		<	100		<	100		<	100	
Chloroform	ug/L	<	50		<	500		<	50		<	50		<	50		<	50	
Chloromethane	ug/L	<	130		<	1300		<	130		<	130		<	130		<	130	
Dibromochloromethane	ug/L	<	50		<	500		<	50		<	50		<	50		<	50	
1,1-Dichloroethane	ug/L	<	50		<	500			360		<	50		<	50		<	50	
1,2-Dichloroethane	ug/L	<	50		<	500		<	50	M/	<	50	M/	<	50		<	50	M/
1,1-Dichloroethene	ug/L		294		<	1200		<	120			335			24.5	F/		245	
cis-1,2-Dichloroethene	ug/L		134000	/KFT		3270	/LFT		142000	/KT		144000	/KT		19100	/KFT		101000	/KT
trans-1,2-Dichloroethene	ug/L		1870			644	F/		2020			1910			710			1700	
1,2-Dichloropropane	ug/L	<	50		<	500		<	50		<	50		<	'50		<	50	
cis-1,3-Dichloropropene	ug/L	<	50		<	500		<	50		<	50		<	50		<	50	
trans-1,3-Dichloropropene	ug/L	<	50		<	500		<	50		<	50		<	50		<	50	
Methylene chloride	ug/L	<	50		<	500		<	50		<	50		<	50		<	50	
1,1,2,2-Tetrachloroethane	ug/L	<	50		<	500		<	50		<	50		<	50		<	50	
Tetrachloroethene	ug/L	<	140		<	1400		<	140		<	140		<	140		<	140	
Trichloroethene	ug/L	<	100		<	1000			40.4	M/		39.4	M/	<	100		<	100	M/
1,1,1-Trichloroethane	ug/L	<	50		<	500		<	50		<	50		<	50		<	50	
1,1,2-Trichloroethane	ug/L	<	100		<	1000		<	100		<	100		<	100		<	100	
Vinyl chloride	ug/L		63000	/KT		95200	/LT		35100	/KT		33100	/KT		47000	/KT		71400	/KT

Summary of Analytical Test Results
Deep Monitoring Wells
Cape Canaveral Air Station
November 1998 Sampling

Sample ID / Date Collected / Lab Sample ID		C-HGRK-PRTMWD16 11/18/98 L9811380-12		C-HGRK-PRTMWD17 11/18/98 L9811380-08		C-HGRK-PRTMWD18 11/18/98 L9811380-03		C-HGRK-PRTMWD19 11/19/98 L9811380-23		C-HGRK-PRTMWD19-a 11/19/98 L9811380-24		C-HGRK-PRTMWD20 11/18/98 L9811380-13	
Bromodichloromethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100	
Carbon tetrachloride	ug/L	< 210	R/	< 210		< 210		< 210		< 210		< 210	
Chlorobenzene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
Chloroethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100	
Chloroform	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
Chloromethane	ug/L	< 130		< 130		< 130		< 130		< 130		< 130	
Dibromochloromethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
1,1-Dichloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
1,2-Dichloroethane	ug/L	< 50		< 50		< 50		< 50	M/	< 50		< 50	
1,1-Dichloroethene	ug/L	< 120		< 120		< 120		340		338		222	
cis-1,2-Dichloroethene	ug/L	4450	/KFT	3270	/KFT	12100	/KFT	137000	/KT	142000	M/KT	107000	/KFT
trans-1,2-Dichloroethene	ug/L	469		645		871		2380		2380		1860	
1,2-Dichloropropane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
cis-1,3-Dichloropropene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
trans-1,3-Dichloropropene	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
Methylene chloride	ug/L	< 50		< 50		25.7	F/LT	< 50		< 50		< 50	
1,1,2,2-Tetrachloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
Tetrachloroethene	ug/L	< 140		< 140		< 140		< 140		< 140		< 140	
Trichloroethene	ug/L	< 100		< 100		< 100		< 100	M/	< 100		< 100	
1,1,1-Trichloroethane	ug/L	< 50		< 50		< 50		< 50		< 50		< 50	
1,1,2-Trichloroethane	ug/L	< 100		< 100		< 100		< 100		< 100		< 100	
Vinyl chloride	ug/L	86100	/KT	86000	/KT	89300	/KT	34700	/KT	36400	/KT	83400	/KT

Summary of Analytical Results
QA/QC Samples
Cape Canaveral Air Station
November 1998

Sample ID / Date Collected / Lab Sample ID		C-HGRK-PRTAMBK09 11/18/98 L9811380-01	C-HGRK-PRTAMBK10 11/19/98 L9811380-18	C-HGRK-PRTEQBK07 11/18/98 L9811380-07	C-HGRK-PRTEQBK08 11/19/98 L9811380-19	C-HGRK-PRTTPBK07 11/18/98 L9811380-10
Bromodichloromethane	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Carbon tetrachloride	ug/L	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1
Chlorobenzene	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Chloroethane	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chloroform	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Chloromethane	ug/L	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3
Dibromochloromethane	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
1,1-Dichloroethane	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
1,2-Dichloroethane	ug/L	< 0.50	< 0.50 M/	< 0.50	< 0.50 M/	< 0.50
1,1-Dichloroethene	ug/L	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
cis-1,2-Dichloroethene	ug/L	0.720 F/	< 1.2	0.460 F/	< 1.2	5.83
trans-1,2-Dichloroethene	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
1,2-Dichloropropane	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
cis-1,3-Dichloropropene	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
trans-1,3-Dichloropropene	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Methylene chloride	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	0.290 F/
1,1,2,2-Tetrachloroethane	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Tetrachloroethene	ug/L	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
Trichloroethene	ug/L	< 1.0	< 1.0 M/	< 1.0	< 1.0 M/	< 1.0
1,1,1-Trichloroethane	ug/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
1,1,2-Trichloroethane	ug/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl chloride	ug/L	< 1.1	< 1.1	< 1.1	< 1.1	45.8

Data Qualifier Explanations
Cape Canaveral Air Station
1998 Sampling Events

Modifier	Description
<	Indicates not detected at the reporting limit indicated. If "J" flags are utilized in the reporting, the "<" indicates not detected down to 10% of the reporting limit indicated.
/	Separates the analytical laboratory data qualifier from the Rust data qualifier (ex., Kemron/Rust).

Kemron Data Flag Descriptions

D	The analyte was quantified at a secondary dilution factor.
F	Present below nominal reporting limit (AFCEE only).
I	Semi-quantitative result, out of instrument calibration range.
M	A matrix effect was present.
R	The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
X	m-Xylene and p-Xylene are unresolvable compounds.

Rust Data Flag Descriptions

A	Field duplicate RPDs exceeded established criteria.
c	Laboratory control recovery below established criteria.
F	Detected in the associated field (i.e., ambient) blank.
I	Surrogate recovery above the upper limit.
J	Estimated value.
K	Common laboratory artifact detected at a concentration greater than 10X that detected in the associated field or laboratory blanks, or some other artifact detected at a concentration greater than 5X that detected in the associated field or laboratory blanks. Professional judgment must be used to determine if the detect is site-related.
L	Common laboratory artifact detected at less than 10X that detected in the associated field or laboratory blanks, or some other artifact detected at less than 5X that detected in the associated field or laboratory blanks. Not considered site-related per EPA data evaluation guidance.
m	Matrix spike sample percent recovery below established limits.
R	The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
T	Detected in the associated trip blank.
V	Detected in the associated equipment rinsate blank.

APPENDIX D

CALCULATIONS

GROUNDWATER PUMP AND TREAT SYSTEM ASSUMPTIONS AND CALCULATIONS

RESULTS OF WELFLO MODEL

The analytical model developed by William Walton, called WELFLO, was used to estimate a single-well drawdown. WELFLO calculates the drawdown for each grid cell specified in the input. A grid area 200 feet wide was specified with each grid cell 10-foot by 10-foot each. The drawdown was output for each of these cells, as influenced by the pumping well. Drawdown is derived from Theis equation calculations. These are not capture-zone calculations, but we assumed that the capture zone extends out to where one-half foot of the pumping-well drawdown remains.

Other assumptions with the use of this analytical model:

- **No recharge** is added; however, since most of the immediate area is paved, very little recharge reaches the area;

- **One hydraulic conductivity value** is input; therefore, a homogenized hydraulic conductivity value was used. A weighted average K was estimated using the K values for the specified depth ranges in Table 3.2 of the 11/96 Hydrogeologic Investigation of the Industrial Area (Parsons). Also, this K-value was applied to the entire thickness of the aquifer.

- A **sensitivity analysis** was performed on the K-value by calculating K-values five times and one fifth that estimated. All three values were used for the WELFLO calculations.

- There is **no ground-water gradient** included. However, since the gradient is so flat at this location, it should not have a significant detrimental influence.

The WELFLO analytical model was run using a range of hydraulic conductivity values (see attached spreadsheet). At a flow rate of 10 gpm, the drawdown at either end of wall length is predicted to be between 0.5 and 0.7 feet with the average hydraulic conductivity (K value). If the K value is greater than average, the results would be less than 0.5 feet.

At 14 gpm, the least amount of drawdown calculated at the ends of the wall lengths was 0.5 feet (using maximum K value and 20x the storage coefficient). This fits our criteria for required drawdown.

This result was then checked using capture-zone width calculations at the average K value and 14 gpm. The result was a 103-foot wide capture zone.

HANGAR K WELFLO RESULTS

14 gpm		Average K		Minimum K		Maximum K		low Zone K
Aquifer Thickness	(feet)	31	31	31	31	31	31	31
K	(ft/d)	101.83	101.83	60.84	60.84	142.83	142.83	13
Storativity		0.001	0.02	0.001	0.02	0.001	0.02	0.001
Flow Rate	(gpm)	14	14	14	14	14	14	14
Pumping Period	(days)	272	272	272	272	272	272	272
Maximum Drawdown	(feet)	1.64	1.43	2.68	2.34	1.18	1.04	11.72
Drawdown @ 50 Feet	(feet)	0.92	0.72	1.44	1.14	0.67	0.53	6.1

10 gpm		Average K	
Aquifer Thickness	(feet)	31	31
K	(ft/d)	101.83	101.83
Storativity		0.001	0.02
Flow Rate	(gpm)	10	10
Pumping Period	(days)	272	272
Maximum Drawdown	(feet)	1.17	1.02
Drawdown @ 50 Feet	(feet)	0.66	0.51

NOTE:
Four K values were used, the fourth, 13 ft/d, is the K for the zone 23 to 37 feet below ground surface.
Two calculations were made for each K, one for the storage coefficient listed and one, 20x greater, for sensitivity.

The 14 gpm appears to have drawdown to have influence over a 100 foot width, for all Ks.

ESTIMATE VOC EMISSIONS FROM AIR STRIPPING

Purpose: The basis of comparison will be equal volumes of water through the systems. The basis of wastewater treatment will be air stripping. In order to perform air stripping, estimates of VOC emissions will be required. Activated carbon may be needed to adsorb stripped VOCs. For this estimate, we have assumed carbon is required.

Data: 1. Analytical data collected during the pilot study from wells upgradient of the walls.

Vinyl Chloride (ug/L), Shallow wells						
Date	MWI01	MWI03	MWI11	MWI13	MWI15	MWI19
Feb-98	0	0	1	3	29	220
Aug-98	0	0	0	2	2	5
Average	0	0	0	2	15	112
Overall Average						**22**

Vinyl Chloride (ug/L), Deep wells						
Date	MWD01	MWD03	MWD11	MWD13	MWD15	MWD19
Feb-98	58,000	5,700	9,800	29,000	34,000	15,000
May-98	33,000	42,000	31,000	26,000	33,000	22,000
Aug-98	70,000	55,600	30,500	25,100	34,700	33,400
Nov-98	70,900	67,400	63,000	35,100	71,400	34,700
Average	57,975	42,675	33,575	28,800	43,275	26,275
Overall Average						**38,763**

cis-1,2-Dichloroethene (ug/L), Shallow wells						
Date	MWI01	MWI03	MWI11	MWI13	MWI15	MWI19
Feb-98	1	0	4	16	65	160
Aug-98	1	1	10	6	8	6
Average	1	1	7	11	36	83
Overall Average						**23**

ESTIMATE VOC EMISSIONS FROM AIR STRIPPING

cis-1,2-Dichloroethene (ug/L), Deep wells						
Date	MWD01	MWD03	MWD11	MWD13	MWD15	MWD19
Feb-98	93,000	35,000	75,000	59,000	160,000	170,000
May-98	57,000	100,000	140,000	150,000	160,000	150,000
Aug-98	89,900	121,000	147,000	151,000	96,800	145,000
Nov-98	69,800	103,000	134,000	142,000	101,000	137,000
Average	77,425	89,750	124,000	125,500	129,450	150,500
Overall Average						**116,104**

trans-1,2-Dichloroethene (ug/L), Shallow wells						
Date	MWI01	MWI03	MWI11	MWI13	MWI15	MWI19
Feb-98	0	0	1	2	5	3
Aug-98	0	0	0	1	2	1
Average	0	0	1	2	3	2
Overall Average						**1**

trans-1,2-Dichloroethene (ug/L), Deep wells						
Date	MWD01	MWD03	MWD11	MWD13	MWD15	MWD19
Feb-98	490	1,600	1,700	1,700	1,900	2,200
May-98	800	1,600	1,900	2,200	2,300	2,500
Aug-98	1,470	1,750	1,790	1,970	1,440	2,260
Nov-98	1,160	1,580	1,870	2,020	1,700	2,380
Average	980	1,633	1,815	1,973	1,835	2,335
Overall Average						**1,762**

ESTIMATE VOC EMISSIONS FROM AIR STRIPPING

1,1-Dichloroethene (ug/L), Shallow wells						
Date	MWI01	MWI03	MWI11	MWI13	MWI15	MWI19
Feb-98	0	0	0	0	0	0
Aug-98	0	0	0	0	0	0
Average	0	0	0	0	0	0
Overall Average						**0**

1,1-Dichloroethene (ug/L), Deep wells						
Date	MWD01	MWD03	MWD11	MWD13	MWD15	MWD19
Feb-98	0	190	250	270	240	260
May-98	0	0	0	270	300	0
Aug-98	173	231	316	318	193	280
Nov-98	142	212	294	0	245	340
Average	79	158	215	215	245	220
Overall Average						**189**

Assumptions:

1. Non-detects assumed concentration = 0.
2. Concentrations from shallow wells apply to upper 30 feet of capture zone
3. Concentrations from deep wells apply to lower 15 feet of capture zone

Mass Flow Rates:

Upper 30 Feet	Flowrate =	10.8 gpm
		90 lbs/min
		129704 lbs/day
Constituent	**Concentration (ug/L)**	**Mass (lbs/day)**
vinyl chloride	22	0.002815
cis-1,2-dichloroethene	23	0.002998
trans-1,2-dichloroethene	1	0.00017
1,1-dichloroethene	0	0

ESTIMATE VOC EMISSIONS FROM AIR STRIPPING

Lower 15 Feet	Flowrate =		
		2.8 gpm	
		23 lbs/min	
		33627 lbs/day	
Constituent	**Concentration (ug/L)**		**Mass (lbs/day)**
vinyl chloride	22		0.000730
cis-1,2-dichloroethene	23		0.000777
trans-1,2-dichloroethene	1		0.000044
1,1-dichloroethene	0		0.000000

Layer 3:	Flowrate =		
		0.4 gpm	
		3 lbs/min	
		4804 lbs/day	
Constituent	**Concentration (ug/L)**		**Mass (lbs/day)**
vinyl chloride	38,763		0.19
cis-1,2-dichloroethene	116,104		0.56
trans-1,2-dichloroethene	1,762		0.01
1,1-dichloroethene	189		0.00

OVERALL	Flowrate =		
		14.0 gpm	
		116.8 lbs/min	
		168134.4 lbs/day	
Constituent	**Weighted Average Concentration (ug/L)**		**Mass (lbs/day)**
vinyl chloride	38,039		0.19
cis-1,2-dichloroethene	115,324		0.56
trans-1,2-dichloroethene	1,718		0.01
1,1-dichloroethene	189		0.00

ESTIMATE GROUNDWATER TREATMENT REQUIREMENTS

Purpose: To provide a comparison of costs for groundwater pump and treatment.
Determine requirements of treatment system to process an equal volume of water

Data: Estimated volume of water through the PeRT walls for a period of 10 months
Analytical results from grounwater sampling.

Flowrate =	14 gpm	
vinyl chloride	38,039 ug/L	0.19 lbs/day
cis-1,2-dichloroethene	115,324 ug/L	0.56 lbs/day
trans-1,2-dichloroethene	1,718 ug/L	0.01 lbs/day
1,1-dichloroethene	189 ug/L	0.00 lbs/day

Define System
1: Air Stripper followed by liquid and vapor phase carbon
2: Liquid phase carbon polish

Assumptions:
1. Assume air stripping is 95% effective at removing VOCs from water.
2. Assume all stripped VOCs to vapor phase carbon, removed to no detectable emissions
3. Assume all VOCs remaining ion water after air stripping are collected on liquid phase GAC.

Mass Flows:

Constituent	To Air Stripper (lbs/day)	To Vapor Phase GAC (lbs/day	To Liquid Phase GAC (lbs/day)
vinyl chloride	0.19	0.1803	0.0095
cis-1,2-dichloroethene	0.56	0.5334	0.0281
trans-1,2-dichloroethene	0.01	0.0082	0.0004
1,1-dichloroethene	0.00	0.0009	0.0000
Total VOCs	**0.76**	**0.72**	**0.04**

Recommendations from Calgon Carbon:

Vapor Phase: 1,800 lb plastic units
Need 12 over 10 months

Each cost for delivery, return, placement:	$3,585
monthy rental fee per unit	$275
Acceptance testing	$1,000

Liquid Phase - cyclesorb FP-2 Unit, 2,000 lbs
17 Units over 10 months

L:\work\concept\39748\report\draft final\flow

ESTIMATE GROUNDWATER TREATMENT REQUIREMENTS

Each cost for delivery, return, placement:	$1,800
monthy rental fee per unit	$790
Acceptance testing	$1,000

Part 1: Installed Equipment Costs

Item	Units	No. Units	Unit Cost	Cost	Source
Site Prep/Restoration					
Mobilization	LS	1	$1,100	$1,100	Cost on PeRT Wall project
Cut asphalt for wells & pipe trench	LS	1	$1,700	$1,700	Cost on PeRT Wall project
Trenching/Backfill	LS	1	$2,268	$2,268	Cost on PeRT Wall project
Slab on Grade, 6"	SF	1250	$4.28	$5,350	Echos, 97, 18 02 0322
Remove/Dispose asphalt	SY	67	17.75	$1,183	Cost on PeRT Wall project
Replace Asphalt	SY	67	14.09	$939	Cost on PeRT Wall project
Reseeding	LS	1	$150	$150	Cost on PeRT Wall project
Subtotal				*$12,691*	
Extraction Wells, Vaults, Influent Piping and Controls Installation					
Driller Mobilization	LS	1	$400	$400	Cost on PeRT Wall project
4" Stainless Steel well casing	LF	25	$54	$1,350	Echos, 97, 33 23 0122
4" Stainless Steel well screen	LF	15	$65	$975	Echos, 97, 33 23 0222
3/4 HP pumps, 230V, controls	Each	1	$5,715	$5,715	Echos, 97, 33 23 0602
Explosion proof electrical	Each	1	$420	$420	Echos, 97, 33 23 0811
Drill & Test wells	LF	40	$55	$2,200	Echos, 97, 33 23 1143
Control Panel, at treatment equipmen	Each	1	$7,052	$7,052	Echos, 97, 33 23 1302
Well vaults, traffic load	Each	1	$3,319	$3,319	Echos, 97, 33 23 1302
Piping, 1" stainless steel +M fittings	LF	200	$13.30	$2,660	Echos, 97, 33 26 0231
Subtotal				*$24,091*	
Treatments System, effluent piping and controls Installation					
Air Stripper, Purchase	Each	1	$7,500	$7,500	Delta Cooling Towers
Level Controls (NEMA 7)	Each	1	$1,080	$1,080	Delta Cooling Towers
Explosion proof fan motor	Each	1	$525	$525	Delta Cooling Towers
Control Panel	Each	1	$3,130	$3,130	Delta Cooling Towers
Shipping	Each	1	$1,000	$1,000	Delta Cooling Towers
Air Stripper, Install	Each	1	$39,705	$39,705	Assume equip = 1/4 installed
Liquid GAC Deliver initial cells	Each	2	$1,800	$3,600	Calgon
Liquid GAC rental fee, each unit	Each	2	$790	$1,580	Calgon
Liquid GAC Testing fee	Each	1	$1,000.00	$1,000	Calgon
Vapor GAC Deliver initial cells	Each	2	$3,585.00	$7,170	Calgon
Vapor GAC rental fee, each unit	Each	2	$275.00	$550	Calgon
Vapor GAC Testing fee	Each	1	$1,000.00	$1,000	Calgon
Discharge piping to sewer	LF	75	$5.65	$424	Echos, 97, 19 02 0101
Precast manhole	Each	3	$612.95	$1,839	Echos, 97, 19 02 0201
550 Gal Steel Sump	Each	1	$1,110	$1,110	Echos, 97, 19 04 0602
Backflow Preventor	Each	1	$1,000	$1,000	Guess
Subtotal				$72,213	
Monitoring Well Installation					
Total Installation per well	Each	4	$1,419	$5,677	Cost on PeRT Wall project

L:\work\concept\39748\report\final\flow

Construction Oversight

Construction oversight - labor	Day	60	$593	$35,580	Cost on PeRT Wall project
Construction oversight - expenses	Month	3	$2,556	$7,668	Cost on PeRT Wall project
Subtotal				$43,248	

Miscellaneous Other Direct Costs

IDW sampling	Each	3	$1,262	$3,786	Cost on PeRT Wall project
IDW storage	Month	1	$300	$300	Cost on PeRT Wall project
IDW transport	Each	1	$1,250	$1,250	Cost on PeRT Wall project
IDW disposal	Ton	10	$55	$550	Cost on PeRT Wall project
Port-O-Lets	Month	3	$74	$222	Cost on PeRT Wall project
Barricades	Month	3	$386	$1,158	Cost on PeRT Wall project
Subtotal				*$7,266*	
TOTAL INSTALLED COST				**$165,187**	

Part 2: Operations and Maintenance - 10 Months

Packing Recondition	EA	0	$2,094	$0	Echos, 97, 33 13 0701
Blower and Motor maintenance	EA	1	$356	$356	Echos, 97, 33 41 0201
Pump Maintain	EA	1	$356	$356	Echos, 97, 33 41 0101
Electrical	KWH	9,274	$0.03	$306	Typical Industrial Rates
Sewage Surcharge	Gal	6,048,000	$0.01	$60,480	Typical Water Treatment Rates, large volume, good quality.
Carbon Change out - liquid phase	Each	15	$1,800.00	$27,000	Calgon
Liquid Phase rental units	Each	15	$790.00	$11,850	Calgon
Carbon Change out - vapor phase	Each	10	$3,585.00	$35,850	Calgon
Vapor Phase rental units	Each	10	$275.00	$2,750	Calgon
Subtotal O&M				*$138,948*	

Monitoring - Quarterly Sampling

Labor	Each	4	$10,695	$42,780	Cost on PeRT Wall project
Laboratory Analysis, 5 samples	Event	4	$550	$2,200	Cost on PeRT Wall project

Monitoring - Effluent - collect monthly samples. Four events combined with quarterly sampling

Labor (monthly combine with 4 above	Each	6	$400	$2,400	Estimated cost travel, sampling
Laboratory Analysis, 10 samples	Each	10	$110	$1,100	Cost on PeRT Wall project

Monitoring - Carbon emissions. Weekly OVA checks, weekly liquid grab. Combine with monthly events

Labor (Weekly - combine with above)	Each	33.33333	$400	$13,333	Estimated cost travel, sampling
Laboratory Analysis, grab samples	Each	43.33333	$110	$4,767	Cost on PeRT Wall project
Subtotal Monitoring				$66,580	

Delta Cooling Towers, Inc.
134 Clinton Road
P.O. Box 952
Fairfield, New Jersey 07004
Telephone 201/227-0300
Fax 201/227-0458

Delta Cooling Towers

FAX: 864-234-3069

November 20, 1998

Ms. Kathleen McNelis
Earth Tech
15 Brendan Way
Greenville, SC 29356

Subject: **Vanguard®** Air Stripper

Dear Ms. McNelis,

Thank you for the subject RFQ faxed to me on 11/18, through Delta's web site and for the opportunity to submit a Delta air stripper proposal for your consideration.

Delta can provide a **Vanguard®** Model ΔS1-100 air stripper for this application designed to reduce cis-1,2 dichloroethene, trans-1,2 dichloroethene, 1,1 DCE and vinyl chloride <95% at an influent flow rate of 14 gpm of contaminated water @ 80 to 90° F.

This air stripper is a 1' diameter FRP packed column with 10 feet of **Delta-Pak®** structured packing, and a TEFC 480/3/60 blower/motor assembly.

The budget price for this stripper, FOB Fairfield, N. J., including an aluminum ladder and safety cage, and guy wire attachments, is $7,500.00.

Shipment can be made approximately 6-8 weeks after receipt of formal authorization to proceed with fabrication. Our general air stripper literature and specification data sheets are attached for your reference.

I trust this proposal is complete and satisfies your requirements, however if there are any questions, or if we can be of further assistance please do not hesitate to contract us.

Thank you for your interest in Delta and its products, and for the opportunity to be of service.

Sincerely,
John T. Halligan
John T. Halligan
Vice President

Delta Cooling Towers Inc.
134 Clinton Road
P.O. Box 952
Fairfield, New Jersey 07004-2970
Telephone 973/227-0300
Fax 973/227-0458

Delta Cooling Towers

Delta Cooling Towers, Inc. was founded to manufacture and market the initial concept of a maintenance free seamless one-piece non-corrosive Polyethylene cooling tower, and sold its first units in June, 1971.

In 1981 Delta entered the air stripper market and currently markets a standard line of **VANGUARD®** air strippers from 1' through 5' diameter. Larger custom system designs can been provided up to 15' diameter.

Delta prides itself in its ability to provide the technical expertise necessary to meet the requirements of any application with respect to stripper design, materials of construction, type of packing and total system capability. Some of our recent systems, for both easy and difficult stripping applications, are discussed in our general literature.

Delta's **PIONEER®** forced draft cooling tower line is factory assembled in single modules from 10 through 100 tons of cooling capacity.

Delta's **PARAGON®** induced draft cooling towers are also factory assembled in single modules, from 100 to 250 tons in single modules.

Delta's **PREMIER™** induced draft cooling towers are provided "factory complete", no field assembly required, designed for ease of installation to span existing cooling tower structural supports, from 250 to 500 tons where larger capacity is required.

For more information about Delta and its products call (973) 227-0300, or fax your request to (973) 227-0458.

You may also visit our Web Site: http://www.deltacooling.com, or reach us by E-mail: deltacooling@worldnet.att.net.

Thank you for your interest in Delta and its products.

Delta Cooling Towers Inc.
134 Clinton Road
P.O. Box 952
Fairfield, New Jersey 07004-2970
Telephone 973/227-0300
Fax 973/227-0458

Delta Cooling Towers

DELTA AIR STRIPPERS-BENEFITS

•VANGUARD®-standard models-proven design, economics, short delivery.

•CUSTOM strippers-up to 10 ft. diameter, 2000 gpm water flow.

•Basic MATERIALS OF CONSTRUCTION:
-high performance structured modular packing.
-film type, PVC.

•STATIC PRESSURE LOSSES of DELTA-PAK®:
-about 4 to 30 times lower than dumped packings, depending on type and conditions.
-fan horsepower requirements are typically lower than those of competing systems (lower operating costs).

•FLOODING CHARACTERISTICS of DELTA-PAK®:
-superior to dumped packings.
-water loadings in excess of 20 gpm/sq. ft. can be handled at air flow rates 600 to 700 cfm/sq. ft. (about 3000 lb/hr. sq. ft.) and higher.

•HIGH MASS TRANSFER coefficients.

•REMOVAL RATES-correspondingly high:
-99.9% and higher in a single stripper (1) at only 20 to 25 foot overall height, 1,000,000 to 1 or higher contaminant reduction in two stripping stages is possible (1).

•Stripping of "HARD-TO-STRIP" compounds (4):
-often very efficient with DELTA VANGUARD® air strippers, without preheating, with low blower HP. Consult others.

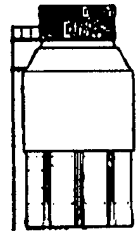
•MODULAR construction (2): utilizing prepacked, preassembled standardized sections.

•FUTURE UPGRADING is possible on most models.

•ERECTION TIME-normally hours (3). LIGHT WEIGHT.

•ACCESSORIES, CONTROLS are available. SYSTEMS can be supplied.
•ASSISTANCE, SERVICE, SUPPORT

1) Removal of TCE, PCE, benzene and many other compounds, subject to water flow treated.
2) Delta VANGUARD® standard air strippers.
3) Particularly in skid mounted stripper installations.
4) Compounds with low Henry's law constant, generally.



Delta Cooling Towers Inc.
134 Clinton Road
P.O. Box 952
Fairfield, New Jersey 07004-2970
Telephone 973/227-0300
Fax 973/227-0458

Delta Cooling Towers

July 1992

TECHNICAL SPECIFICATIONS
DELTA VANGUARD AIR STRIPPERS (FORCED DRAFT TYPE)

Delta Air Strippers are designed to remove volatile organic chemicals and certain other substances from water.

A blower, ducted into the sump plenum provides air at a slight positive pressure and forces it to flow upward against the downward trickling water. This is a countercurrent forced draft design.

As the air passes over the water, spread over the packing surface as a thin film, the molecules of contaminant cross the air/water interface and enter the air stream. The air then exits the column either to atmosphere or to some means of vapor phase remediation process.

Delta **VANGUARD®** Air Strippers possess known, predetermined stripping performance and operational characteristics based upon field test data obtained from independent sources.

Stripper shell. The shell material is a hand lay-up FRP isophthalic polyester resin of sufficient thickness to withstand the specified operating conditions, as well as external loads imposed from earthquake Zone 4 and 120 mile/hour wind loading. Guy wiring is standard; free-standing design is available as an option. The shells are designed using the ASME/ANSI RTP-1-1989 Rev. 1991 Standards as a guide.

Treated water collection sump is integral with lower part of the shell, forming a one piece, seamless component. The sump is provided with outlet and other required connections, and incorporates a blower duct for air supply to the stripper. Access and inspection port is provided in the sump plenum.

Connections (outlet, inlet and others) are constructed of FRP and are fully gasketed with neoprene gaskets. 3" and larger connection sizes are flanged (150# flanges), smaller than 3" size connections are NPTF. All flanges up to and including 4"are gussetted.

Water distribution system is constructed of Type 1 PVC. Uniform water distribution is effected (on 6SS Series Air Strippers and smaller) by a single full cone, non-clog PVC spray nozzle which provides uniform water loading to the entire packing surface. The typical nozzle flow turn - down ratio is 2/1. For flows up to 350 GPM the nozzle is threaded into the inlet header via an NPTM thread and can be readily removed and replaced. Nozzles for flows greater than 350 GPM are 6" 150# flange connections.

Packing. Delta Pak®, used in all standard stripper models, is a high performance structured packing constructed of Type 1 PVC material protected against UV degradation.

Applicable data below is for air - water atmospheric system:

Surface area:	90 sq. ft./cu.ft.
Void space:	Higher than 98%
Open cross-section:	Higher than 98%
Maximum air flow before flooding, at 20 gpm/sq.ft.:	750 scfm/sq. ft. or higher
Static pressure loss at 20 gpm/sq.ft. and 500 scfm/ sq. ft. air flow:	0.10 in. W.C./ft. or lower
Orientation of corrugation:	Vertical ("see - through")
Nominal corrugation size:	Approx. 3/4 in.
"Channelling" characteristics:	No channeling occurs. Packing construction prevents any radial transfer of mass, due to its spirally wound configuration. Transfer in tangential direction is negligible.
"Clogging" and "fouling" characteristics:	The absence of any horizontally oriented surfaces reduces accumulation of precipitates and deposition of suspended solids. Most solids including precipitates pass freely through packing along vertical corrugations.

Standard packing layer heights: 12.6 in. and 6.3 in.

Mist eliminator is Delta AB mist eliminator, constructed of Type 1 PVC material, compounded with carbon black for UV resistance. The eliminator is designed to minimize drift loss to lower than 0.02% of the water flow.

Depth:	12 in.
Type:	Crimped plate, impingement type

Blower ΔS1 and ΔS1.5 use a cast aluminum/bronze radial bladed wheel. The unit is arrangement 4 and is directly driven by a 3450 RPM motor. ΔS2 uses a backwardly inclined centrifugal blower wheel. The unit is arrangement 10 and is belt driven by a 3450 RPM TEFC motor. ΔS3 through ΔS5 uses an airfoil blade design for most efficient and quiet operation. The unit is arrangement 10 and is belt driven with an 1800 RPM TEFC motor.

Skid used with skid-mounted strippers (an option) is a welded steel frame with 10 ga. plate decking, coated with black air dried phenolic paint.

Fasteners and other hardware: Type 304 SS

Standard features:

- Motors are TEFC design with a minimum 1.15 SF.
- Provided with a motor/drive weather enclosure or guard (ΔS5)
- Belt drive units are provided with vibration isolation and blower to duct neoprene bellows.
- Designed based upon tests made in accordance with ASHRAE Standard 51 and AMCA Standard 210-74, and are licensed to carry the AMCA SEAL.
- Factory dynamically balanced and checked against the acceptable levels on the Rathbone Chart.
- Standard coating is an industrial baked enamel. Other coatings are available and provided based upon AMCA Recommended Practice NO. 2601-66

Delta Vanguard®
Air Strippers

Delta Delivers Clean Clear Water

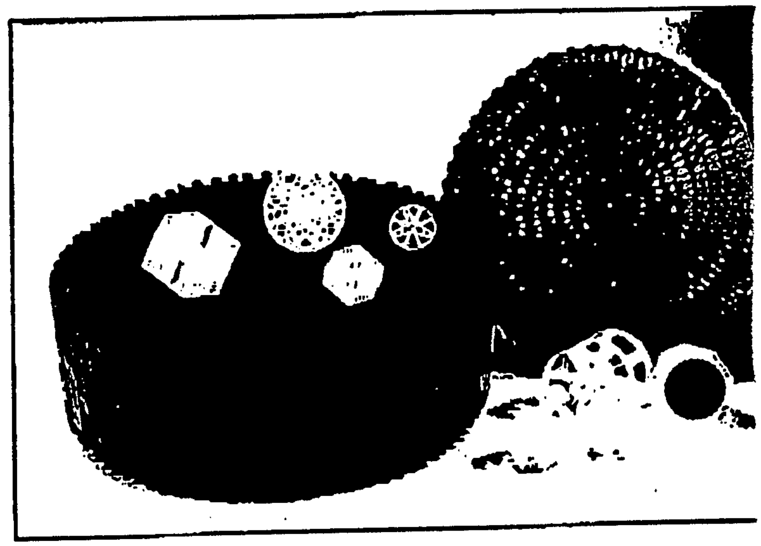
Recent recognition of the massive scale of groundwater contamination has given rise to the development of specific treatment technologies. Adapting the proven mass transfer process of air stripping to remediation of contaminated groundwater has proven to be the most economical. Early on, Delta applied its strong design expertise to this problem and now has a decade of practical experience with field installations throughout the United States.

Delta Experience

Since Delta received its first groundwater remediation air stripper order in 1981 it has provided hundreds of innovative and economical solutions for stripping applications. Air stripping has become the preferred water remediation technology for removal of organic solvents, chlorinated hydrocarbons, fuel/gasoline hydrocarbons, degreasers, and certain other volatile organic chemicals (VOCs), because it is the most cost effective with respect to initial, operating and maintenance costs. Delta's broad knowledge and experience enabled the company to design and develop the Delta Vanguard® line of standard air strippers, which are suitable for most applications. Delta's Vanguard® air stripper systems are preferred for routine as well as for many applications with difficult to strip compounds. The equipment selection process is simpler and often less costly.

Air Stripping — The Packing

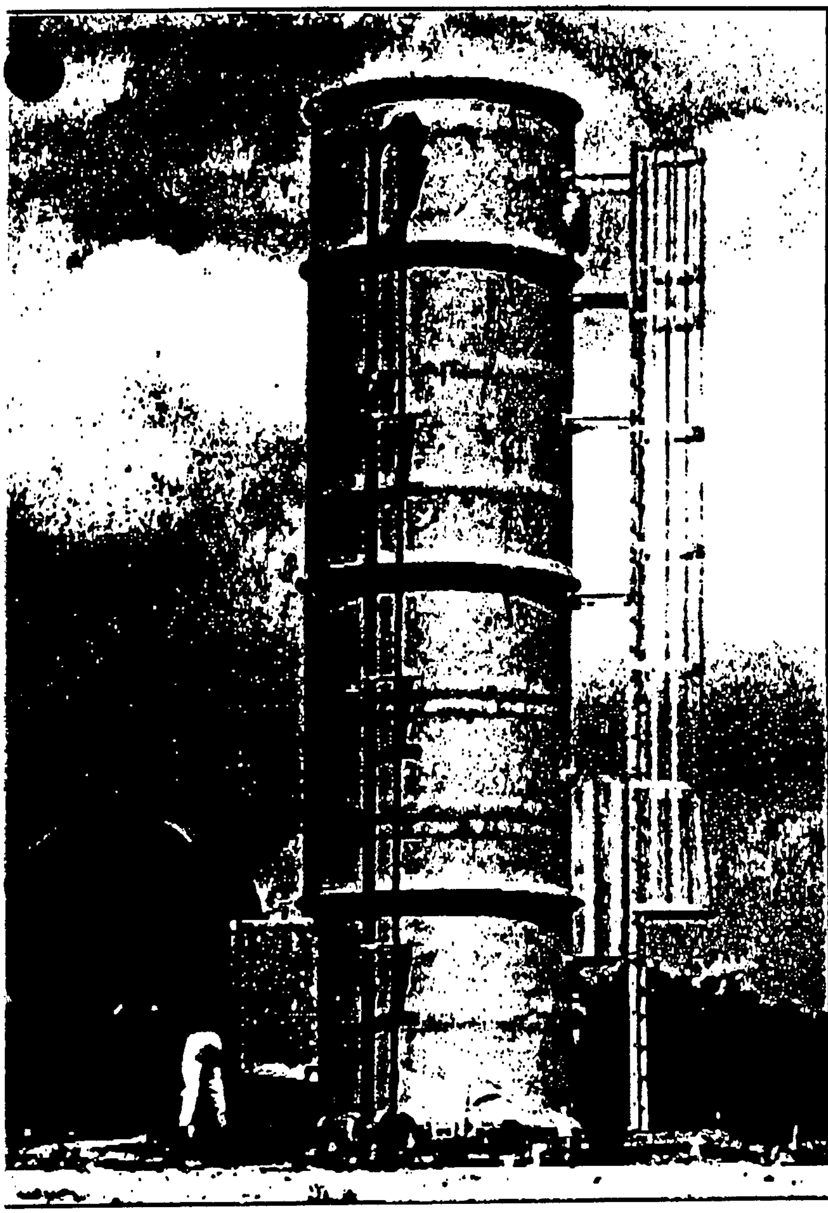
The heart of any air stripper is the packing. Operational parameters, such as a compound's ease of removal, the mineral content of the water which can induce fouling, and air flow requirements as related to the necessity for vapor phase treatment, often dictate a preferred packing media. Delta designs and supplies strippers utilizing all packing types and will recommend the most suitable for your specific situation. Delta can provide any type and size of commercially available random packing, in addition to Delta-Pak®. This proprietary structured packing manufactured by Delta is often the preferred mass transfer media.



Delta-Pak® — Major Advantages

Delta-Pak® is a specially formed PVC, spirally wound structured packing media, which, when installed in an air stripper, becomes a series of long, parallel tubes the length and diameter of the column. This design permits a large volume of uncontaminated airflow, which in turn facilitates efficient stripping. This unique Delta-Pak® media has proven very successful removing compounds that have low Henry's Law Constants, (a relative measure of volatility), such as ammonia and pesticides, which are considered difficult to strip.

Front Cover:
ΔS5 - 210 air stripper, 5' Dia. x 31' - 9 1/2" high, 350 GPM - Benzene 99.4% removal. MTBE 97.5% removal, Napthalene 91.4% removal.



ΔS9-190 Ammonia air stripper, 9' Dia. x 33'-10" high. 70 GPM-250,000 ppb influent, 50,000 ppb effluent, 80% removal.

Another significant advantage of Delta-Pak® is its resistance to fouling. Mineral buildup restricts airflow which reduces efficiency. Since Delta-Pak® is designed to operate at much higher air flows than random packing, contaminant removal efficiency remains high by comparison, and the problems of flooding, bridging, etc. are significantly reduced. Delta-Pak® has become the packing of choice when groundwater contains high mineral content. Actual experience with applications containing high levels of dissolved iron has demonstrated that Delta-Pak® structured packing operates efficiently several times longer than random packing.

Delta Provides a Wide Range of Custom Solutions

Over the years, Delta has developed a wide range of standard options and accessories to meet the demanding requirements of air stripper systems. Delta's experience and technical expertise guarantees the design and manufacture of custom components that will meet environmental compliance requirements.

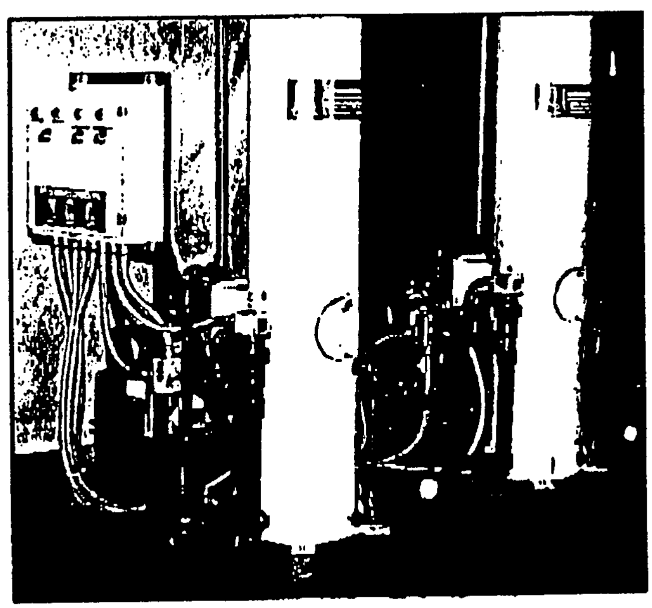
Air Emission Controls — Delta offers appropriate vapor recovery systems including carbon adsorbers.

Chemical Cleaning Systems — Delta developed this option to ensure long term operation, at maximum efficiency, and to minimize or eliminate packing replacement.

Instrumentation, Controls and Telemetry — Delta provides systems to integrate pressure, flow, overflow, fail-safe and transfer control systems for remote monitoring and data collection.

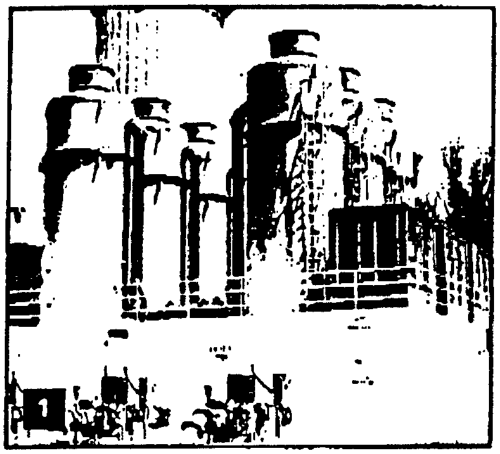
Corrosive Environments — Delta designs major components in Fiberglass (FRP), Stainless Steel or Aluminum.

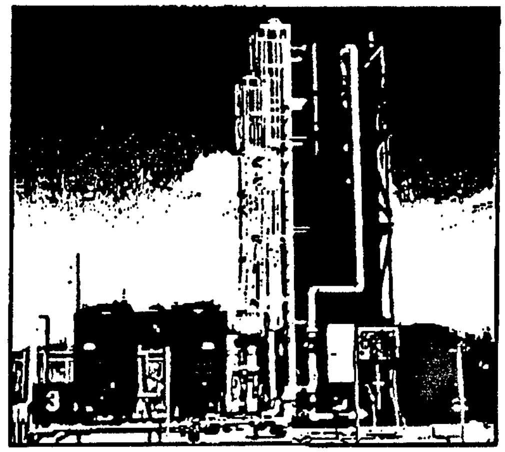
Extreme Winter Conditions — Delta has the experience necessary for successful cold weather applications, which are a particular challenge to air strippers.

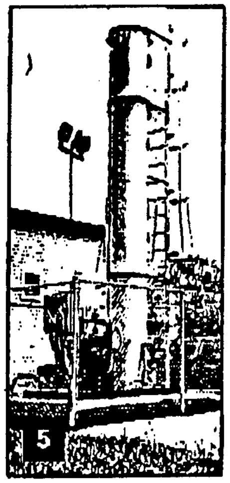


A dual Vanguard model ΔS1-145 air stripping system skid mounted pre-piped and pre-wired. 5 GPM-Methylene Chloride and 1,1,1,TCA 99.99% removal, Benzene 96.2% removal, Toluene 88.9% removal.

DÈLTA, PROVIDING PRODUCTS FOR A SAFE ENVIRONMENT







[1] (6)ΔS9-100 Hydrogen Sulfide Strippers, 9' Dia. x 24' High, 1500 GPM each unit - 8,000 ppb influent. 400 ppb effluent. 95% removal. [2] ΔS7-235 with dual blowers, 1000 GPM -TCE 99.7% removal. 1.1.1. TCA 97.1% removal, t,1,2, DCE, Chloroform, Xylenes 90% removal. [3] (2) ΔS4-185T. 210 GPM-1,1,1,TCA, 1,1,DCE, 1,1, Dichloroethane, PCE 99.93% removal. [4] ΔS2-145 Ammonia Air Stripper, 12 GPM-90% removal of NH_3. [5] ΔS2-145, 30 GPM-t,1,2,DCE,TCE, 1,1,1,TCA, 1,1,DCE, 1,1,DCA 95.7% removal. [6](2)ΔS6-150, 6' Dia. x 25'-9" High, 625 GPM-Total Xylenes 97.6% removal, Chlorobenzene 96.6% removal, Benzene 94.8% removal, Napthalene 92.3% removal.

Delta Experience

Delta Air Strippers have been provided

- As custom designed systems tailored to specific needs
- As integrated equipment systems with automatic process controls, completely pre-assembled, skid mounted, pre-piped, pre-wired and hydrostatically/electrically factory tested
- With vapor phase air emission control devices
- With chemical cleaning, and other system packages
- For pilot test systems

For Further Information:

Delta Cooling Towers, Inc.
134 Clinton Road
P.O. Box 952
Fairfield, New Jersey 07004-2970
Telephone 973/227-0300
Fax 973/227-0458
E-mail deltacooling@worldnet.att.net
Website www.deltacooling.com

Major Benefits

Delta air strippers

- Are constructed of Fiberglass, Stainless Steel or Aluminum
- Are available with skid mounted options
- Can be provided free standing or guy wired
- Are provided with proven packing design, usually pre-packed in column prior to shipment
- Are modular, pre-assembled and lightweight for simple, fast, economical installation
- Apply modular design concepts for easy upgrade
- Have demonstrated effective removal of contaminants considered difficult, and in some circles, impossible to strip
- Are usually the most economical treatment option

Delta Cooling Towers

Request for Information and Budget Quote

Requested by: Kathleen McNelis
Earth Tech
15 Brendan Way
Greenville, SC 29615
Phone: 864-234-8910
Fax: 864-234-3069

Liquid and Vapor Phase carbon

Project: Groundwater treatment, effluent and air emissions from an air stripper
Duration: 10 months
Location: Cape Canaveral, Florida

Liquid: Groundwater temperature = 80F, Flow rate = 14 gpm
Vapor: Air temperature = 90F, 300 cfm, saturated

Hours of operation, 24/day, 7,300 total in 10 months (project duration)

Constituents to be adsorbed:

Chemical	lbs/day to vapor phase	lbs/day to liquid phase
vinyl chloride	0.1803	0.0095
cis-1,2-dichloroethene	0.5334	0.0281
trans-1,2-dichloroethene	0.0082	0.0004
1,1-dichloroethene	0.0009	0

Information requested:

1. Estimated rate of usage of each type carbon
2. Recommended vessel for each carbon type
3. Estimated cost for each type carbon
4. Rental rates on vessels (if rental available)
5. Cost to deliver carbon
6. Cost to reclaim carbon

CALGON

CALGON CARBON CORPORATION
1120 ROUTE 22 EAST
BRIDGEWATER, NEW JERSEY 08807-2985

(908) 526-4646 PHONE (908) 526-2467 FAX

FAX MEMO

TO: Kathleen McNelis DATE: 5-21-99

ATTN: Earth Tech NO. OF PAGES WITH COVER 3

FROM: Stephanie Carr
James McNeill

TRANSMISSION ERROR CALL NUMBER ABOVE

SUBJECT: GW Treatment, Cape Canaveral, Fl.

MESSAGE: Revision 2 - 5/14/99

(1) Vapor - 300 cfm, Estimated carbon usage is 74 lbs. Pellet BG carbon/Day
12 Vapor Pacs/10 Months

(2) Liquid - 14 GPM
Vinyl chloride is still first compound to breakthrough at estimated usage rate of 116 lbs. react carbon/day. If you do not need to treat for VC, then next species

to breakthrough the carbon bed is cis 1,2-DCE,
at 28 lbs React Carbon / Day.

So for Vinyl chloride (and all voc) removal
Cyclesorb FP-2 (2000 lbs.) every 17 Days

OR Based on allowing VC to breakthrough
GAC bed and just removing 1,2 DCE cis &
trans, cyclesorb FP-1 (1000 # carbon unit)
every 35 Days
OR 5 units / 6 months

FP-1 pricing (service) as follows:

FP-1 1000 lbs. react carbon
placement Fee .... $ 1200 / unit
FOB Pittsburg
PA

Monthly Service Fee ...... $ 400 / mo / unit

Plus spent carbon acceptance test fee as before
and spent return freight (to PA or KY)

Request for Information and Budget Quote

Requested by: Kathleen McNelis
Earth Tech
15 Brendan Way
Greenville, SC 29615
Phone: 864-234-8910
Fax: 864-234-3069

Liquid and Vapor Phase carbon

Project: Groundwater treatment, effluent and air emissions from an air stripper
Duration: 10 months
Location: Cape Canaveral, Florida

Liquid: Groundwater temperature = 80F, Flow rate = 14 gpm
Vapor: Air temperature = 90F, 300 cfm, saturated

Hours of operation, 24/day, 7,300 total in 10 months (project duration)

Constituents to be adsorbed:

300 cfm 14 GPM

First to Breakthrough Carbon **

Chemical	lbs/day to vapor phase		lbs/day to liquid phase	
		PPMV		PPM
** vinyl chloride	0.1803	2.7	0.0095	.056
cis-1,2-dichloroethene	0.5334	5.1	0.0281	.167
trans-1,2-dichloroethene	0.0082	.08	0.0004	.002
1,1-dichloroethene	0.0009	.009	0	

Estimate 74# Carbon / Day
12 Vapor Pacs / 10 Months

Information requested:

1. Estimated rate of usage of each type carbon
2. Recommended vessel for each carbon type
3. Estimated cost for each type carbon
4. Rental rates on vessels (if rental available)
5. Cost to deliver carbon
6. Cost to reclaim carbon

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

CALGON

CALGON CARBON CORPORATION

CALGON CARBON CORPORATION
VAPOR PAC SERVICE PRICING

With the Vapor Pac Service, Calgon Carbon provides the adsorber, the vapor phase carbon, spent carbon handling and reactivation. The adsorber is easily transportable and normally contains 1,800 pounds of carbon, but can also be supplied with 1,000 lbs. of carbon. The unit is available in 2 basic designs: polyethylene (plastic) and stainless steel. The attached product bulletin provides additional information regarding the 2 units.

Pricing

Pricing excludes any applicable taxes.
Pricing excludes freight charges.
Payment terms are net 30 days.
Equipment is owned and maintained by Calgon Carbon Corporation.

Plastic or Stainless Steel Vapor Pac Placement Fee 3,5 85/unit

Includes 1,800 pounds of Pellet BG pelleted virgin vapor phase carbon, spent carbon handling and reactivation.

Monthly Fee .... $275.00 (Plastic Unit)

Carbon Acceptance Fee

Prior to return of the first unit for reactivation, we are required to sample the spent carbon to ensure a safe reactivation process. This is a one time per site charge.

Non-RCRA Acceptance.................................$400.00
RCRA Acceptance...$1000.00

Freight

Above pricing is F.O.B. Calgon Carbon Corporation

CALGON
CALGON CARBON CORPORATION

CALGON CARBON CORPORATION
CYCLESORB SERVICE AND CYCLESORB PRICING

With the Cyclesorb Service, Calgon Carbon provides the adsorber, the liquid phase activated carbon, spent carbon handling and reactivation. The unit is available in three basic designs, Cyclesorb FP-1, Cyclesorb FP-2 and Cyclesorb S.S.. The FP-1 contains 1,000 lbs. of carbon and FP-2 contains 2,000 lbs., and both are made from corrosion resistant fiberglass-wrapped polyethylene, with an operating pressure rating of 75 psig at 140 degree F. The Cyclesorb S.S. contains 2,000 lbs. of carbon and is made from 316 stainless steel, with an operating pressure rating of 15 psig.

Pricing

- Pricing excludes any applicable taxes and freight charges.
  Payment terms are net 30 days.

Standard Service	FP-2
Placement/exchange fee-react (includes reactivation)	$ 1800
Monthly fee	$ 790

Carbon Acceptance Fee

Prior to return of first unit for reactivation, we are required to evaluate a spent carbon sample to ensure a safe reactivation. There is a one-time charge for each application, as follows:

Non-RCRA spent carbon acceptance	$400
RCRA spent carbon acceptance	$1000

Optional Cyclesorb Pipe Rack

$2,468
(4-6 wks delivery)

The pipe rack will allow two Cyclesorbs to be operated in parallel series, (with either adsorber placed in first stage).

ips 12/98

CALGON

CALGON CARBON CORPORATION

SERVICE BULLETIN

VAPOR PAC

Calgon Carbon's Vapor Pac Service meets industrial needs for cost-effective removal of volatile organic compounds (VOCs) at air emission sources.

The Vapor Pac Service features a small, easily transportable adsorber which contains 1,800 pounds of activated carbon. The adsorber can handle air flows up to 1,000 cfm.

Designed to remove both toxic and non-toxic VOCs, the adsorption system is especially useful for short-term projects and for treatment of low volume flows that contain low to moderate VOC concentrations. Common applications include VOC removal from process vents, soil remediation vents, and air stripper off-gases.

To accommodate a wide variety of process conditions, Vapor Pac adsorbers are available in two basic designs: a polyethylene model that offers excellent corrosion-resistance, and a stainless steel model that can withstand higher temperatures, and slight pressure or vacuum conditions.

Calgon Carbon provides the adsorber, carbon, spent carbon handling and carbon reactivation (after the carbon meets the company's acceptance criteria) as part of the Vapor Pac Service. Ductwork and fans are the only equipment requiring a capital expenditure by the user.

When carbon becomes saturated with VOCs, the system is replaced with another adsorber containing fresh carbon.

By utilizing this unique service, users can generally achieve VOC removal and regulatory compliance objectives, minimize operating costs, and eliminate maintenance costs* (as the equipment is owned and maintained by Calgon Carbon). Furthermore, because organic compounds are safely destroyed through the carbon reactivation process, costs and regulations typically associated with waste disposal can be eliminated.

Please contact a Calgon Carbon Technical Sales Representative to learn more about the advantages of the Vapor Pac Service for your specific VOC control needs.

**Damage to Vapor Pac Unit caused by negligence or misapplication is the responsibility of the user.*

FEATURES AND BENEFITS OF VAPOR PAC SERVICE

- Adsorbers are specifically designed for ease of installation and operation.
- Adsorbers are available in plastic (polyethylene) and metal (stainless steel) construction to accommodate a wide variety of applications.
- System can be operated in series or parallel mode or a combination of both modes to handle a variety of flows and concentrations.
- System exchange eliminates on-site carbon handling.
- Recycling of spent carbon eliminates disposal problems.
- Capital expenditure is eliminated since Calgon Carbon Corporation owns and maintains equipment.

VAPOR PAC (PLASTIC) SPECIFICATIONS

Vessel dimensions: ....44¼" x 44¼" x 89¾"

Inlet & discharge connections: ....6" PS 15-69 duct flanges

Carbon volume: ....60 cu. ft. (1800 lbs)

System shipping weight: ....New - 2400 lbs
Spent - 4200 lbs

Temperature rating: ....150°F max

Static pressure rating above carbon level: ....20" W.C. max

Vacuum pressure rating above carbon level: ....2" W.C. max

All units shipped F.O.B., Pittsburgh, Pennsylvania

MATERIALS OF CONSTRUCTION

Vessel: ....Polyethylene

Frame: ....Epoxy coated carbon steel

Inlet flanges, elbow, septum: ....PVC

Discharge flange: ....Polyethylene

Fasteners & bottom valve support plate: ....Steel, plated

Sample fittings & sample canister: ....PVC

VAPOR PAC (STAINLESS STEEL) SPECIFICATIONS

Vessel dimensions, diameter: ....5'
height: ....7'1"

Inlet & discharge connections: ....8" PS 15-69 duct flanges

Carbon volume: ....60 cu. ft. approx. (1800 lbs)

System shipping weight: ....New - 2800 lbs
Spent - 4600 lbs

Static pressure rating above carbon level: ....15 psig

Vacuum pressure rating above carbon level: ....Full

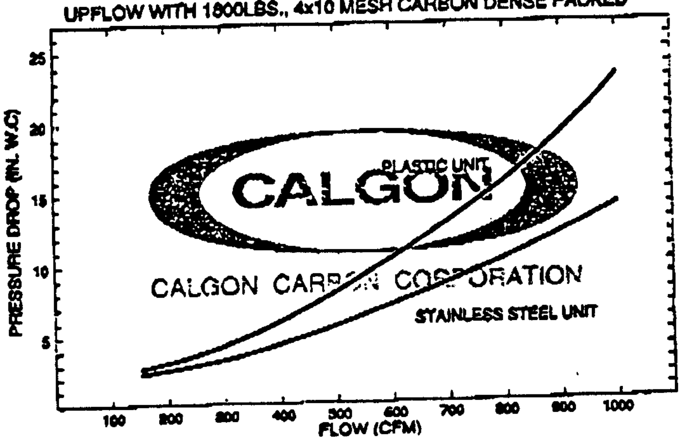
All units shipped F.O.B., Pittsburgh, Pennsylvania

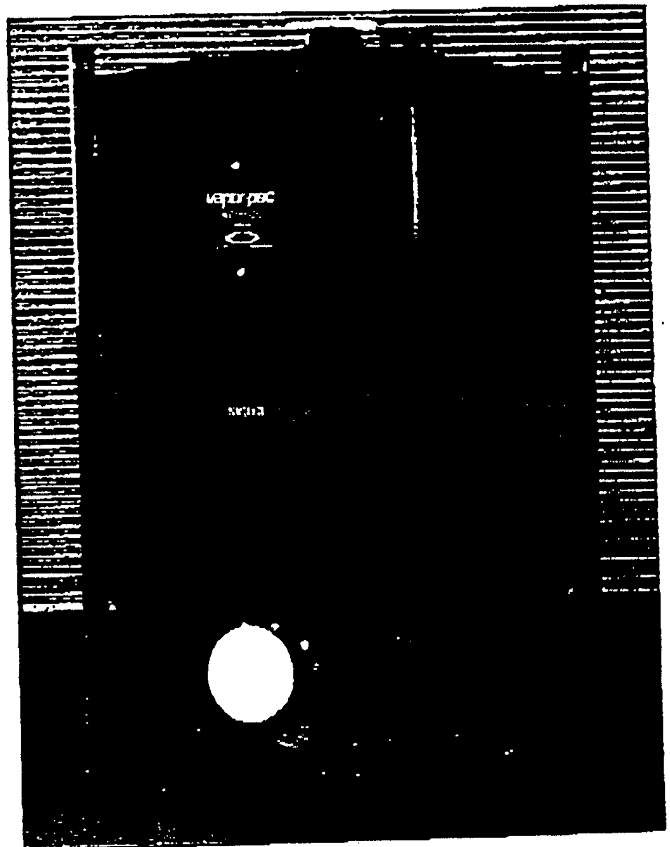
CALGON CARBON CORPORATION • P.O. BOX 717 • PITTSBURGH, PA 15230-0717 • PHONE 1-800-4CARBON

MATERIALS OF CONSTRUCTION

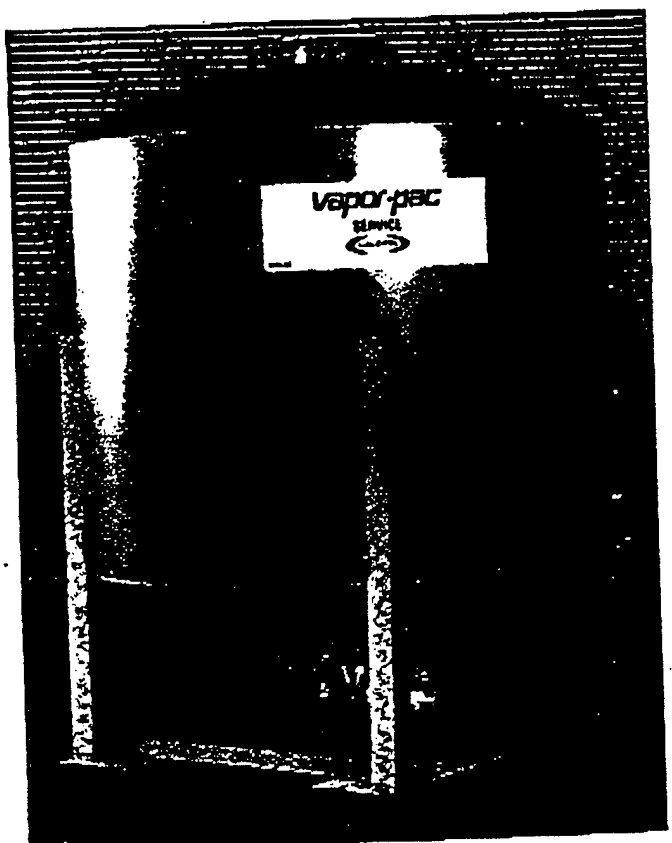
Vessel: .... 316L stainless steel
Skid and support frame: .... 304 stainless steel
Inlet flanges, elbow, septum: .... 316L stainless steel
Discharge flange: .... 316L stainless steel
Fasteners & bottom valve: .... 300 series stainless steel
Sample fittings & sample canister: ....PVC

VAPOR PAC UNIT PRESSURE DROP
UPFLOW WITH 1800LBS., 4x10 MESH CARBON DENSE PACKED





VAPOR PAC - PLASTIC



VAPOR PAC - STAINLESS STEEL

CAUTION

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing activated carbon, appropriate sampling and work procedures should be followed, including all applicable federal and state requirements.

For information regarding human and environmental exposure, call Calgon Carbon's Regulatory and Trade Affairs personnel at (412) 787-6700.

INSTALLATION INSTRUCTIONS

See Bulletin #LS-27-0199 for details on how to install a Vapor Pac.

SAFETY CONSIDERATIONS

See Safety Bulletin #TI-006-08/94 for important safety considerations.

OPTIONAL EQUIPMENT

Inlet and outlet flange adaptors for ANSI flange or stub hose connections.

For additional information, contact
Calgon Carbon Corporation,
Box 717, Pittsburgh, PA 15230-0717,
Phone 1-800-4-CARBON

CALGON
CALGON CARBON CORPORATION

EQUIPMENT BULLETIN

CALGON

CALGON CARBON CORPORATION

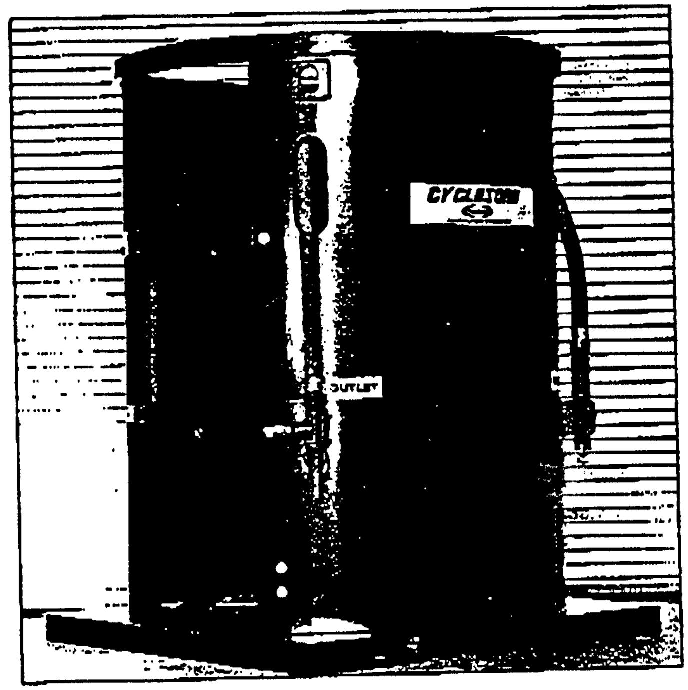
CYCLESORB℠ FP2

GENERAL DESCRIPTION

Calgon Carbon's Cyclesorb FP2 is a compact, portable liquid treatment unit that contains all the essential elements of a full scale carbon adsorption system. Containing 2000 pounds of granular activated carbon, the Cyclesorb FP2 can treat up to 60 gpm for removal of dissolved organic contaminants. When treatment is complete, the Cyclesorb FP2 becomes a convenient shipping container which can be returned to Calgon Carbon for safe reactivation of the spent carbon.

The Cyclesorb FP2 is ideal for many low flow or short duration treatment projects, including:

- Groundwater contaminated by leaking underground storage tanks
- Wastewater stored in tanks or lagoons
- Chemical spills
- Small wastewater or process streams
- Storage tank or pipeline washing
- Off-spec product batches
- Dechlorination or decolorization
- Pump tests
- Feasibility or pilot plant studies



FEATURES

Flexibility - The Cyclesorb FP2 treats the liquid downflow through a fixed bed of granular activated carbon, and therefore can handle varying flows and on-off operating conditions. The units can be arranged in parallel to treat higher flows, or can be connected in series to optimize carbon usage.

Recommended Design - The Cyclesorb FP2 has flexible connections to the FRP vessel to eliminate potential for piping stress on the vessel, and a metal frame to protect the FRP vessel from damage during shipping and handling.

Corrosion Resistance - The Cyclesorb FP2 adsorber is made from fiberglass-wrapped polyethylene, and the piping and other accessories are made from industrial plastics to give the system the capability to handle a wide range of corrosive wastewaters or liquids.

Higher Operating Pressures - The Cyclesorb FP2 adsorber vessel is rated to 150 psig in accordance with NSF-44 Standards, and the prepiped assembly has a maximum operating pressure of 75 psig at 140°F.

Granular Activated Carbon - The Cyclesorb FP2 unit can be provided with any of Calgon Carbon's extensive product line of granular activated carbon. Calgon Carbon's Technical Service Representative can assist in selecting the most cost effective carbon for specific applications.

Safe Spent Carbon Handling - When treatment is complete, the Cyclesorb FP2 becomes the shipping container for the return of the spent carbon to a Calgon Carbon reactivation facility. This feature eliminates the need to handle spent carbon at the site. When returned to Calgon Carbon, the spent carbon is safely reactivated, and all the adsorbed contaminants are thermally destroyed.

Service or Purchase Options - The Cyclesorb FP2 is available on a service or purchase basis. With the service option, Calgon Carbon retains ownership of the unit, takes responsibility for inventory and maintenance, and provides a new unit when the spent unit is to be removed so continuous treatment is assured. If the Cyclesorb FP2 is purchased, Calgon Carbon can provide refill and maintenance service.

SPECIFICATIONS

Granular activated carbon per unit	2,000 lb (908 kg)
Maximum operating pressure	75 psig (517 kPa) @ 140°F
Pressure relief	Graphite rupture disk @ 75 psig
Vacuum rating	Must be protected against vacuum
Temperature rating	140° F (60°C)
Wetted parts materials	High density polyethylene polypropylene, PVC, graphite, viton ethylene propylene rubber
Connections	1 1/2" Kamlock (inlet / outlet) 1/2" FNPT (sample/vent/drain) 2" Kamlock (carbon fill) 3" FNPT (carbon discharge)
Frame	Epoxy Mastic painted metal
Frame dimensions	69" X 69" X 92" height (1750 mm x 1750 mm x 2337 mm height)
Lifting	Fork lift truck or crane (2 eyelets provided)
Weights	Empty: 1,750 lb. (795 kg) With dry carbon (ship): 3,750 lb. (1700 kg) With wet, drained carbon (return): 5,750 lb. (2610 kg) Operating: 8,100 lb. (3675 kg)

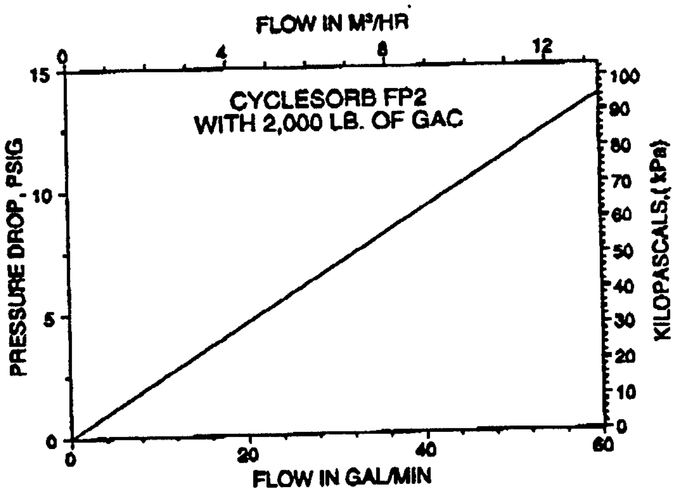
RETURN FOR REACTIVATION

The Cyclesorb FP2 unit serves as a safe and convenient shipping container to return the spent carbon to Calgon Carbon for reactivation. Spent carbon reactivation is an integral component of the Service Agreement where Calgon Carbon provides a unit with fresh carbon to replace the unit being returned. If the unit is purchased, Calgon Carbon still is able to offer exchange services incorporating most of the return and refill elements of the Cyclesorb Service.

Prior to reactivation, an acceptability test is conducted on a small carbon sample provided with the initial Cyclesorb FP2 adsorber, which is exposed to the water or wastewater to simulate spent carbon characteristics. After this test is complete, carbon acceptance documentation is provided to allow return of the initial and subsequent Cyclesorb FP2 units used in the same service.

When treatment is complete, the Cyclesorb FP2 adsorber is drained of liquid, capped and shipped back to a Calgon Carbon reactivation facility. Calgon Carbon's Flexible Service Plan also offers services such as transportation assistance and on-site exchange Services. A Technical Sales Representative will be able to review the many options available for purchase, service, return and carbon exchange.

At the reactivation facility, the spent carbon is thermally reactivated and the adsorbed organic contaminants are destroyed. The Cyclesorb FP2 units are cleaned, inspected, maintained and returned to inventory. Cyclesorb FP2 units are then taken from ready inventory, filled with the specified carbon and provided to the next Service customer for replacement or start of treatment.



PRECAUTIONARY STATEMENTS

Do not strike vessel or subject it to impact, as such practices will damage the structural integrity of the unit.

The rupture disk must not be plugged or restricted, as the system must be able to relieve overpressurization to prevent component failure or vessel rupture. The installation must include vacuum relief, as vacuum created by a siphon loop or other means will cause collapse of the internal vessel wall and leakage.

The system includes flexible connections on the inlet and outlet. These flexible connectors should not be replaced by rigid piping, as expansion of the vessel under pressure could cause damage to the piping or the vessel.

CAUTION Wet activated carbon preferentially removes oxygen from the air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate sampling and work procedures should be followed, including all applicable federal and state requirements. For information regarding human and environmental exposure, call (412) 787-6700 and request to speak to Regulatory and Trade Affairs.

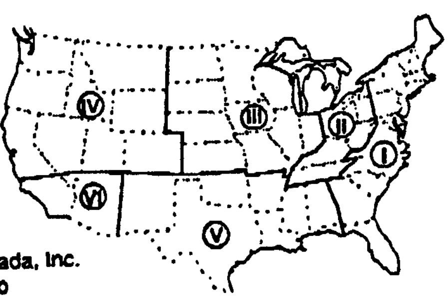
For detailed information on the products described in this bulletin, please contact one of our Regional Sales Offices located nearest to you:

Region I
Bridgewater, NJ
Tel (908) 526-4646
Fax (908) 526-2467

Latin America/Australasia/Philippines
Pittsburgh, PA
Tel (412) 787-4519
Fax (412) 787-4523

Singapore/Asia Pacific
Calgon Carbon Corp.
Tel (65) 221-3500
Fax (65) 221-3554

Region IV
Burlingame, CA
Tel (415) 548-2040
Fax (415) 344-2029



Region II
Pittsburgh, PA
Tel (412) 787-6700
800/4-CARBON
Fax (412) 787-6676

Region V
Houston, TX
Tel (713) 690-2000
Fax (713) 690-7909

Region III
Lisle, IL
Tel (708) 505-1919
Fax (708) 505-1936

Canada
Calgon Carbon Canada, Inc.
Mississauga, Ontario
Tel (905) 673-7137
Fax (905) 673-6883

Europe
Chemviron Carbon
Brussels, Belgium
Tel 32 2 773 02 11
Fax 32 2 770 93 94

Region VI
Carlsbad, CA
Tel (619) 431-5550
Fax (619) 431-6169

If at any time our products or services do not meet your requirements or expectations, or if you would like to suggest any ideas for improvement, please call us at 1-800-548-1999. From outside the U.S. please call +1-412-787-6700.

CALGON

CALGON CARBON CORPORATION

GEOCHEMICAL PARAMETERS

Calculation of the Amount of Fe dissolved AND Clogging by $Fe(OH)_2$

(1) Due to reaction w/ Dissolved oxygen

$Fe^0 + 2H^+ + \frac{1}{2}O_2 = Fe^{2+} + H_2O$

2 mol of Fe^0 dissolves per mol of O_2

Assumption

0.3 mg/L O_2 goes to 0 mg/L O_2

$$\frac{0.3\,mg}{L} \times \frac{56\,mg\ Fe}{32\,mg\ O_2} = 0.53\,\frac{mg\ Fe}{L}$$

(2) Due to reaction with water

Assume maximum pH is 9.5 ($pH^* = 7.5$)

$Fe^0 + 2H_2O = Fe^{2+} + H_2 + 2OH^-$

$[OH^-] = 10^{-4.5}$ (3.16×10^{-5} mol/L)

2 mols OH^- per mol Fe^0

$3.16 \times 10^{-5}/2 = 1.58 \times 10^{-5}$ mol Fe^0/L

$$1.58 \times 10^{-5}\,\frac{mol\ Fe^0}{L} \times \frac{56{,}000\,mg}{mol} = \boxed{0.89\ mg/L}$$

(3) Due to Reaction w/ DCE

Assume $C^c = 115$ mg/L

$Fe^0 + H_2C_2Cl_2 + H^+ = Fe^{2+} + C_2H_3Cl + Cl^-$

mol wt = 97

1 mol Fe^0 per mol DCE

$$\frac{115\,mg\ DCE}{L} \times \frac{56\,mg\ Fe}{97\,mg\ DCE} = 66\,\frac{mg\ Fe^0}{L}$$

④ Due to reaction w/ VC

$Fe^0 + C_2H_3Cl + H^+ = Fe^{2+} + C_2H_4 + Cl^-$

mol wt = 62.5

1 mol Fe^0 per mol VC

$C^i = 57$ mg/L

$$\frac{57 \text{ mg VC}}{L} \times \frac{56 \text{ mg } Fe^0}{62.5 \text{ mg VC}} = 51 \frac{\text{mg Fe}}{L}$$

Lifetime Calculation

Flux = 27.8 L/yr through 1 dm^2 $\rho \sim 7$ g/mL

$$0.5 \text{ L ZVI} \times \frac{7000 \text{ g ZVI}}{L \text{ ZVI}} = 3500 \text{ g of ZVI}$$

$$\frac{3500 \text{ g yr}}{27.8 \text{ L}} \times \frac{L}{0.118 \text{ g}} = \boxed{1067 \text{ years}}$$

Clogging by $Fe(OH)_2$ $Fe^{2+} + 2H_2O = Fe(OH)_2 + 2H^+$

Volume Reduction

$$\frac{118 \text{ mg Fe}}{L} \times \frac{90 \text{ mg } Fe(OH)_2}{56 \text{ mg Fe}} \times \frac{\text{mL } Fe(OH)_2}{4000 \text{ mg } Fe(OH)_2} = \frac{0.047 \text{ mL } Fe(OH)_2}{L}$$

Assume $\rho = 4$ g/cc ($Fe(OH)_2$) same as FeOOH

$\rho_{Fe^0} = 7.5$ g/cc

Vol. of $Fe(OH)_2$ per dm^2 of wall:

$$\frac{27.8 \text{ L}}{yr} \times \frac{\cancel{0.047}\ 0.031 \text{ mL}}{L} = \frac{0.86 \text{ mL } Fe(OH)_2}{yr}$$

Volume of Fe^0 dissolved

$$\frac{118 \text{ mg Fe}}{L} \times \frac{mL}{7500 \text{ mg}} = \frac{0.016 \text{ mL Fe}}{L}$$

Net Vol lost: 0.047 − 0.016 = 0.031

% of Avail pore space per yr = $\frac{0.86 \text{ mL}}{yr} \times \frac{1}{500 \text{ cm}^3} \times 100 = 0.17\%$ (17% in 100 yrs)

Time to use all pore space = $\frac{1}{0.86} \times 500 \text{ cm}^3 = 581$ yrs

Sulfate Reduction

(refer to Calcite calculation)

Density of FeS = 4.6 g/cc

Max change in SO_4 concentration across wall = 50 mg/L
(all values were below this level)

$$Fe^{2+} + \underset{96 g/mol}{SO_4^{2-}} = \underset{88 g/mol}{FeS} + 2O_2$$ (1 mol SO_4^{2-} per mol FeS)

$$\frac{50 \text{ mg } SO_4}{L} \times \frac{88 \text{ mg FeS}}{96 \text{ mg } SO_4} = \frac{45.8 \text{ mg FeS}}{L}$$

$$\times \frac{cm^3}{4600 \text{ mg}} = 0.01 \frac{cm^3}{L} \text{ FeS}$$ Volume of FeS per L of gw:

Volume of FeS deposited per dm^2 of wall:

$$\frac{24.8 L}{yr} \times \frac{0.01 \text{ cm}^3 \text{ FeS}}{L} = \frac{0.28 \text{ cm}^3 \text{ FeS}}{yr}$$

% of available pore space per year:

$$\frac{0.28 \text{ cm}^3}{yr} \times \frac{1}{500 \text{ cm}^3} \times 100\% = 0.06\%$$

(6% in 100 years)

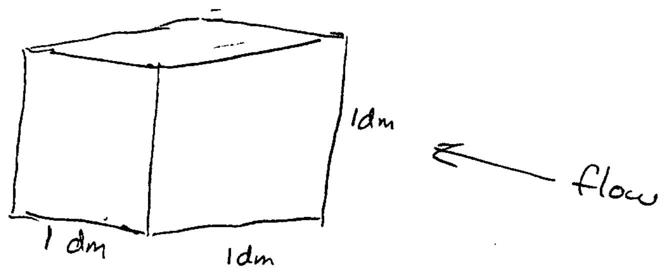
Time to use all available pore space:

$$\frac{1 \text{ yr}}{0.28 \text{ cm}^3} \times 500 \text{ cm}^3 = \underline{1785 \text{ years}}$$

Calculation of clogging by calcite ppt in Deep Zone

Flow rate = 0.025 ft/day (9.1 ft/year) (27.8 dm/year)

Porosity in ZUI = (assumed) 50%



$Ca^{2+} + HCO_3^- = CaCO_3 + H^+$

1 mol HCO_3^- = 1 mol $CaCO_3$

119 mg/L $CaCO_3$ for Intermediate Zone: Time for complete clogging in Intermediate zone is 53/119 × 272 years = 121 years
459 204

Thickness = 4 inches (1.0 dm)

Flux through a 1 dm² section of wall =

$$\frac{27.8\ dm}{year} \times 1 dm^2 = 27.8 \frac{dm^3}{year} \quad (27.8\ L/year)$$

Pore Volume of 1 dm² section = $0.5 \times 1 dm^3 = 0.5\ L$ (500 cm³)

→ Decrease in Alk for Deep Zone across main wall (using Avg values for Nov. 1998): 403 − 350 = 53 mg/L $CaCO_3$
The amount of calcite deposited is approximately twice this value (if predominance is HCO_3^-):

$$\frac{53\ mg\ CaCO_3}{L} \times \frac{meq\ CO_3^{-2}}{100 mg\ CaCO_3} \times \frac{2 meq\ HCO_3^-}{meq\ CO_3^{-2}} \times \frac{100\ mg\ CaCO_3 (calcite)}{meq\ HCO_3^-} = 106 \frac{mg}{L} \text{ Calcite}$$

Density of calcite = 2.7 g/cm³

Volume of calcite deposited per L of gw:

$$\frac{106\ mg\ calcite}{L} \times \frac{cm^3}{2700\ mg} = 0.039 \frac{cm^3\ calcite}{L}$$

Volume of calcite deposited per dm² of wall:

$$\frac{27.8\ L}{yr} \times \frac{0.039\ cm^3\ calcite}{L} = 1.09 \frac{cm^3}{yr}$$

% of Available pore space per year:

$$\frac{1.09\ cm^3}{yr} \times \frac{1}{500 cm^3} \times 100\% = 0.22\% \text{ per year}$$

(22% in 100 years)

Time to use all Available pore space:

$$\frac{1\ yr}{1.09\ cm^3} \times 500\ cm^3 = 459 \text{ years}$$